POWER PLANT ENGINEERING

GENERATION, TRANSMISSION AND UTILIZATION OF STEAM, ELECTRIC, DIESEL AND HYDRAULIC POWER

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OCTOBER
1939

Vol. XLIII., No. 10

Published on the first of each month, copyright 1939 by the
Technical Publishing Co., 53 W. Jackson Blvd., Chicago.
New York Office, 171 Madison Ave.

EDITORIAL STAFF: ARTHUR L. RICE, Editorial Director R. E. TURNER, Editor.
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Subscription price: $2.00 a year in the United States, Possessions and Canada. Other countries $3.50 a year. Single copy price: current issue, 25c; back issues, 40c.

Member, Associated Business Papers, Audit Bureau of Circulations.

Photo, Courtesy General Radio Co.

New Light On Old Subjects

THIS remarkable photograph, obviously has little relation to power plant practice but we thought it of sufficient general interest to deserve a place on this page. Indeed, if we needed an excuse for presenting it, we could find ample justification in the fact that the stroboscope by means of which it was taken has considerable bearing on power plant practice. No recent development has given us quite as much insight into the operation of mechanical equipment, as the high speed stroboscope. This picture shows a bullet passing through an incandescent lamp bulb. The light which crystallized the action could however, with equal facility have shown the exact degree of flexure of a turbine blade moving at 1800 ft. per second. ¶ The principle involved in the stroboscope is not new. Stroboscopes have been built for many years but until the advent of modern electronic technique their speed of action was limited. Using electronic methods however, Dr. Egerton and Kenneth Germeshausen of M.I.T. have developed the stroboscope to a point where time intervals of the order of a millionth of a second can successfully be dealt with. The above picture was taken by the light from one of these stroboscopes with an ordinary camera. The picture speaks for itself. ¶ For certain purposes special cameras are necessary and considerable work in developing such cameras has been done in recent years. One of the most recent achievements in this field is a new camera, developed by General Electric, in connection with circuit breaker studies. This camera is capable of taking 1000 pictures in 1/120 second. In other words, this camera takes pictures at the enormous rate of 120,000 pictures per second. ¶ Poor old Daguerre; wonder what he would say if he could come back to life today and see such a camera. It used to take him an hour to take a single picture. This camera, therefore, is some 432,000,000 times faster, and eloquent measure, incidentally, of progress in photography.

WITH THE EDITORS

Safety in Power Plants

DURING the National Safety Congress to be held in Atlantic City October 16 to 20 awards will be made to a number of utilities for their excellent records in preventing injuries to employes engaged in the performance of their occupations. Considering the extreme hazards in gas and electric plants to which employes are exposed, it is surprising that disabling accidents are not many times more frequent than they are. Yet we find that thirteen companies out of a total of 163 participating in the contest had no disabling accident during the entire year ending June 30, 1939. The total number of employes represented was 162,727, the man-hours 332,867,928, number of injuries 2924, the frequency rate 8.784 per million man-hours which was 13 per cent less than last year. The largest companies, as a rule, had the lowest frequency rates, these being in the combined gas and electric group, but the greatest reduction in accident frequency was reported in the electric company division, the Gulf Power Co. having worked 500,994 man-hours during the entire year without a single disabling injury.

These statistics, while not the best averages reported in recent years, are noteworthy, and the utility companies are to be commended for the continuous efforts they are making to prevent injuries. At best the generation and use of power is filled with hazards that are safe only to the man who knows what to look for and appreciates the significance of defective conditions and incorrect methods of performing duties about the plant.

It is a recognized fact that progress in power generation has been limited in many instances by prevailing safe practices. Steam at almost any pressure is as dangerous as a keg of powder. It must be kept under control. Combustion of fuel in boiler furnaces can, under proper regulation, be carried on safely but slight variations from safe methods frequently result in destructive explosions. Higher speeds of engines, turbines, generators and other revolving equipment were recognized as having many advantages long before it was considered safe to employ them in industry. It took many years to develop materials and auxiliary appliances before modern speeds were considered within the realm of safety. In the electrical field, the upper limit of the voltage employed has been that represented by safety in the use of electricity, since it has long been recognized that resistance losses decrease rapidly with increase in voltage.

Probably the greatest retarding element in the application of present day practices in power plant operation has been the development of operators with sufficient knowledge of materials, forces and processes, together with practical experience to make the more economical practices safe for industrial purposes. It is in this phase of the problem that utilities have made greatest progress and the reason the largest companies had the lowest frequency injury rates is, no doubt, because they are in position to maintain a safety department which devotes its time to keeping employes safety conscious and to training workmen in safe methods and practices. Knowledge, while necessary, is not all that is needed to avoid injuries for the greatest percentage of accidents is the result of carelessness in performing such common activities as walking, climbing, using hand tools and the like. A wandering mind is the greatest danger to safety.

New Technique in Power Accounting

WHEN raw material comes into a factory to be refined, fabricated, machined or otherwise made into a finished product, its value per pound in terms of dollars and cents is necessarily increased in proportion to the amount of work done upon it and other expenses entailed in getting the product to the customer. Certainly a pound of steel fabricated into an electric generator is worth more money to the man who has use for the generator than a pound of steel in the ingots that go to the factory. Steel as a material is only steel, but to the man who has use for a product manufactured from steel, its value per pound in that form may be increased many times.

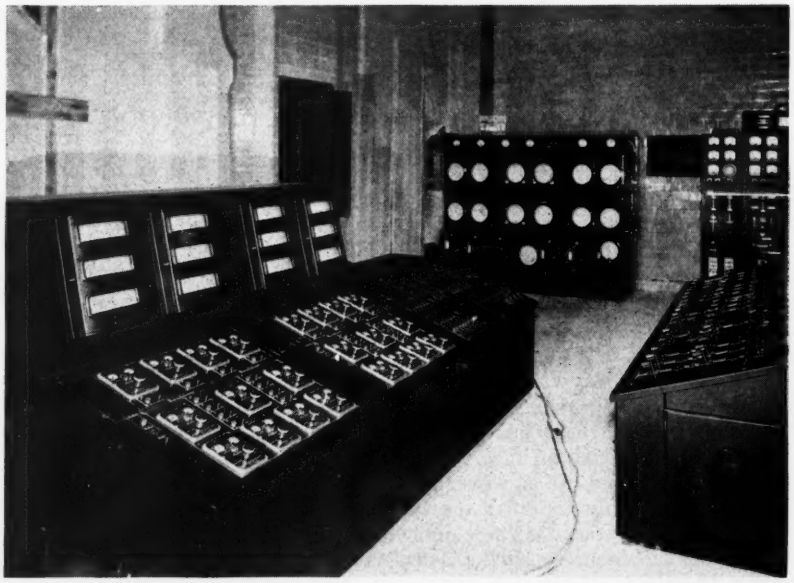
Likewise heat units delivered to the coal pile of a power plant are little in value compared to the equivalent heat units delivered in kilowatts to the transmission line. Those raw heat units have been processed into kinetic energy of considerably more value than the potential energy in the fuel to the man who has use for electrical power. It must not be forgotten, therefore, that the value of a B.t.u. in dollars and cents is extremely variable depending upon the cost of putting the B.t.u. in the form in which it exists. The value of such a unit in furnace gases is not as great as it is in steam; it increases as the pressure and temperature of the steam increase; in the form of electricity it has a still higher value.

When, however, we are dealing with heat units in the same price level, as is done by Mr. Gibbons on another page of this issue, some extremely interesting comparisons can be made which have possibilities of explaining to the owner of a plant some of the more intricate problems of by-product power. If the engineer, who is accustomed to shifting from one equivalent to another in making calculations, can devise a method of accounting for the heat units he is manufacturing into power that makes the various steps and their losses clear to the financial heads of the company, he has gone a long way toward securing cooperation in increasing economy in the plant. Mr. Gibbons' method deserves a try in cases where distinct improvements are blocked by the management.

LANSING'S

Fig. 1. Left. An exterior view of Ottawa Street Station showing the high central section which houses the tall vertical single pass boilers. Note entire absence of stacks

Fig. 2. Below. A view of the central control room. The boiler control board is at the left. Opposite, at the right is the benchboard for the 13.2 kv. electrical system. Above that at the right is the vertical board for the 4160 v. system and at the center rear is the steam distribution panel



RECENT VISITORS to the capital city of Michigan cannot have failed to be impressed by the outstanding features of a new building which has been in process of construction during the past year. Situated in the heart of the city only a few blocks from the state capitol building this new structure commands attention not only because of its size, for it is one of the tallest buildings in Lansing, but also because of its unusual, though pleasing color scheme. Surmounting a base of black granite about six feet high above the foundation, the exterior is faced with gradually varying shades of brick to its full height of 172 feet. Starting with a region of purplish dark gray just above the black base this gradually merges into a deep red. This in turn becomes first bright red and then orange and finally, as the eye travels upward, yellow. At the top the yellow gives way to a yellow gray.

The most interesting feature about this color scheme is that it is not just an arbitrary scheme to suit the fancy of the architect but that there is a definite reason for its use. This building happens to be the new Ottawa Street Electric Generating Station of the City of Lansing and the color scheme is an attempt to symbolize in color the combustion of coal.

Aside from the unusual coloring, the exterior aspects of this station are of perhaps even greater interest because of the entire absence of stacks. When one learns that the building houses some 35,000 kw. of steam-electric generating equipment, the absence of stacks becomes a matter of considerable interest, since, as was pointed out in these very pages not long ago, we have not yet reached the stage in power plant design where stacks can be dispensed with. The fact of the matter is, there *are* stacks but they are concealed.

These matters, while interesting, are quite superficial, however. For real innovation one must study the internal structure of this station, for despite its relatively moderate capacity this generating plant marks one of the greatest advances in power station design that it has been our privilege to record in years. Indeed, not since Bremo Station of the Virginia Public Service Co. was placed in operation in 1931 has anything so modern and so new been introduced to the industry. Incorporating every feature that ten years of high pressure development has proved desirable and with many new ideas which are being put in practice in this plant for the first time, Ottawa Street Station represents a milepost by which technical progress in the industry may well be measured.

As in the case of Bremo Station which was designed by the same group of engineers, Ottawa Street Station is the result of the most careful study and the utmost cooperation between the designing engineers, the manufacturers of equipment and the owners. Every element of its design is based on sound engineering principles and the results of practical experience. Such new ideas as have been incorporated are not experiments but rather the application of proved engineering principles to new purposes. The station was designed from scratch with the object of providing a generating plant having the highest possible efficiency and maximum reliability

NEW OTTAWA ST. STATION

attainable with present day equipment, consistent, of course, with reasonable investment and operating costs. Every piece of equipment and every detail in the cycles of its operation was designed or selected with regard to its influence on the performance of the station as a whole.

The influence of Bremo Station is strongly evident in the design of Ottawa Street Station. The same type of inclined tube, single pass boilers are used; the same type of direct contact extraction heaters and the same system of premeasuring the fuel and air to the furnaces will be found as well as many other features of similarity but in each case the improvements which almost inevitably follow a decade of operation have been incorporated. In the premeasurement of fuel and air for combustion for example, which, in the case of Bremo was under manual control, at Ottawa Street is fully automatic. As in the case of Bremo the architectural character of the building was determined largely by the design of the boiler equipment but at Ottawa Street, the upstanding effect was extended to provide for the entire elimination of visible stacks. This was highly desirable because of the station's location in the heart of the business district of Lansing.

Before we present a detailed description of this interesting station a brief account of the system to which it supplies power will be helpful in serving as a background against which to regard this plant. Municipal operation of an electric generating station is no novelty in the City of Lansing; indeed, for many years the city has operated one of the largest municipal power plants in the country. This is Moores Park Station* with a total capacity of some fifty-five thousand kilowatts. The Board of Water and Light Commissioners also operate a district heating system serving the downtown district.

This heating system until the erection of the new Ottawa Street Station was supplied from two older steam plants, one of which occupied the site of the new Ottawa Street Station. With the completion of this new station the heating system will receive practically its entire supply of steam from this source.

The new station is, therefore, a combined electric generating and district heating plant. Electrically it ties in with Moores Park Station and it is also connected with it by a high pressure steam line some 8000 ft. in length.

Moores Park Station was enlarged to its full capacity by the addition of a 20,000 kw. turbine in 1931. Further expansion at the Moores Park site was undesirable because the station uses a large portion of the available supply of condensing water from the Grand River at that point. It was largely because of this fact that

*November 1, 1931.

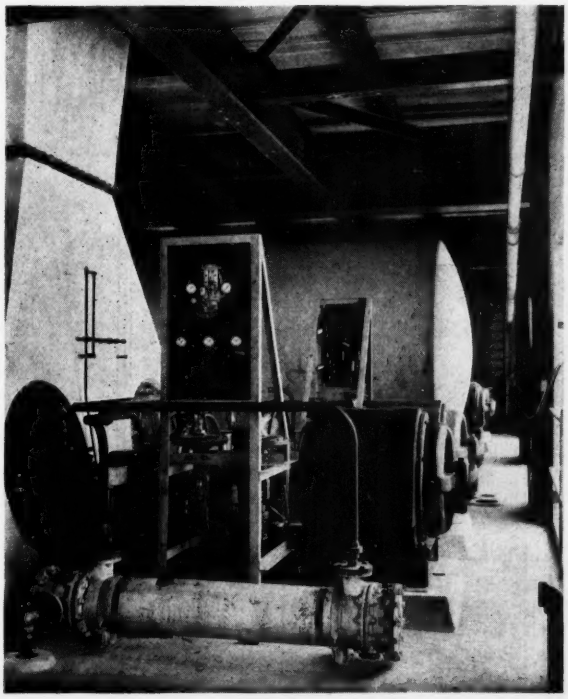


Fig. 3. Above. Looking south on the induced draft fan floor showing the twin motor driven induced draft fans and the hydraulic couplings. The tank in the rear is a 10,000 gal. condensate storage tank

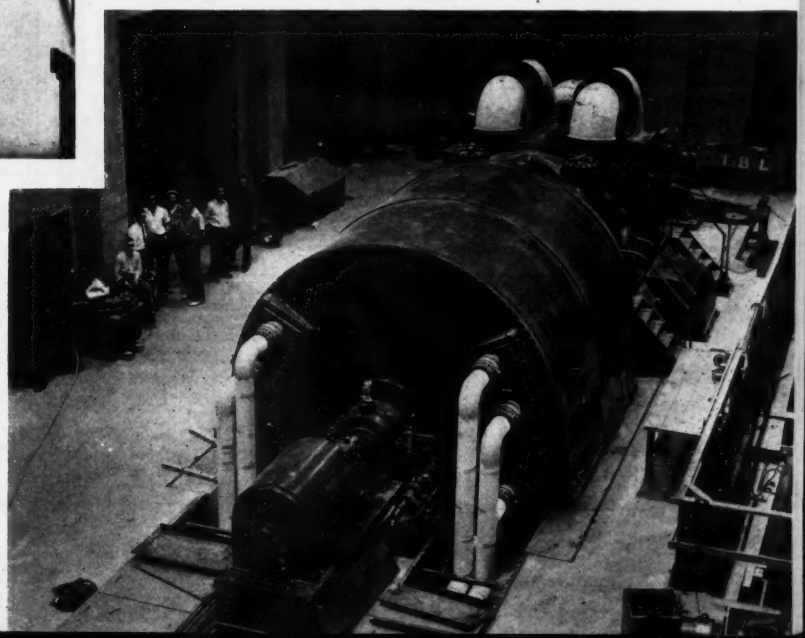
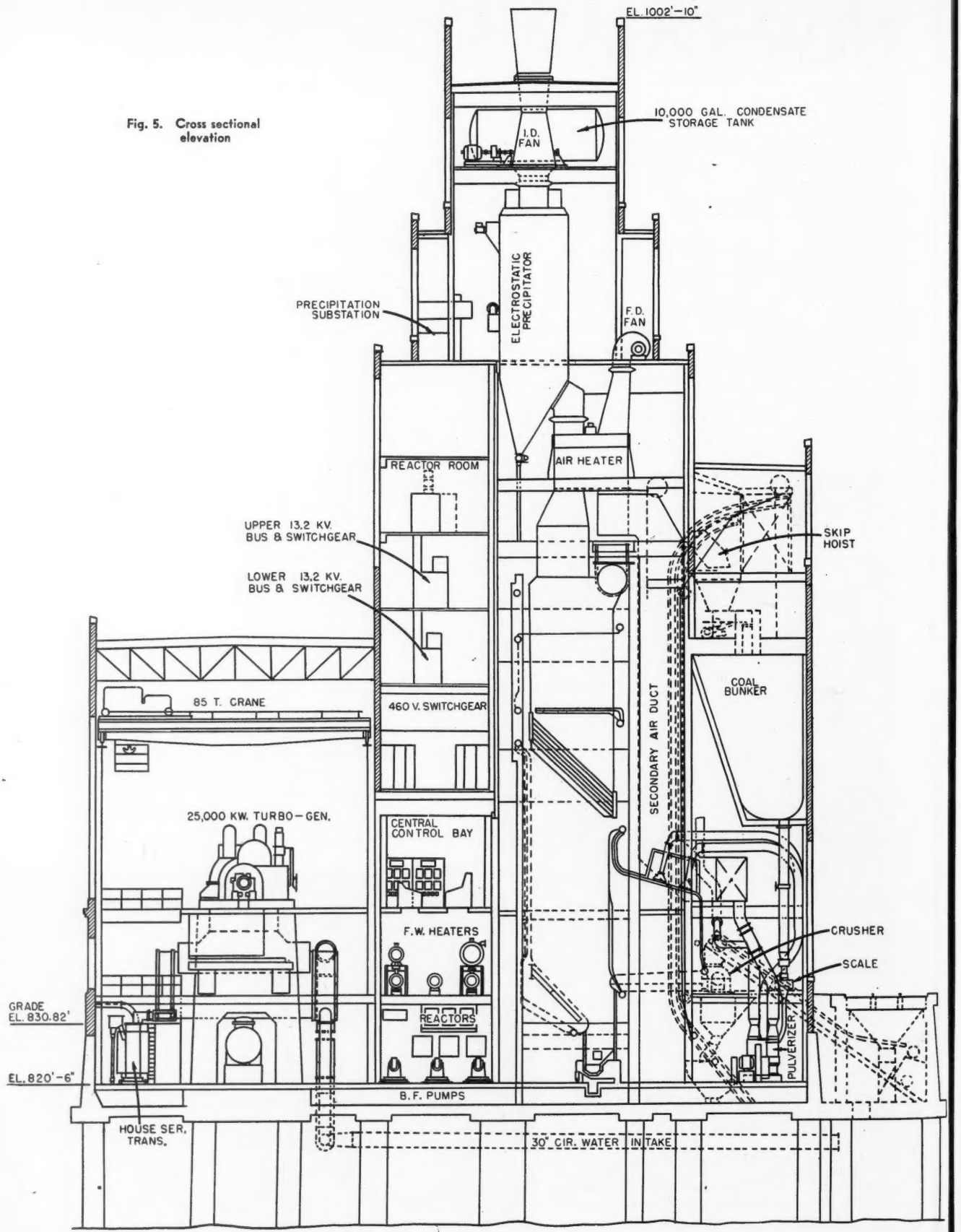


Fig. 4. Right. The 25,000 kw. hydrogen cooled generating unit. This view shows the geared exciter and pilot exciter as well as the four hydrogen coolers built into the generator stator casing

Fig. 5. Cross sectional elevation



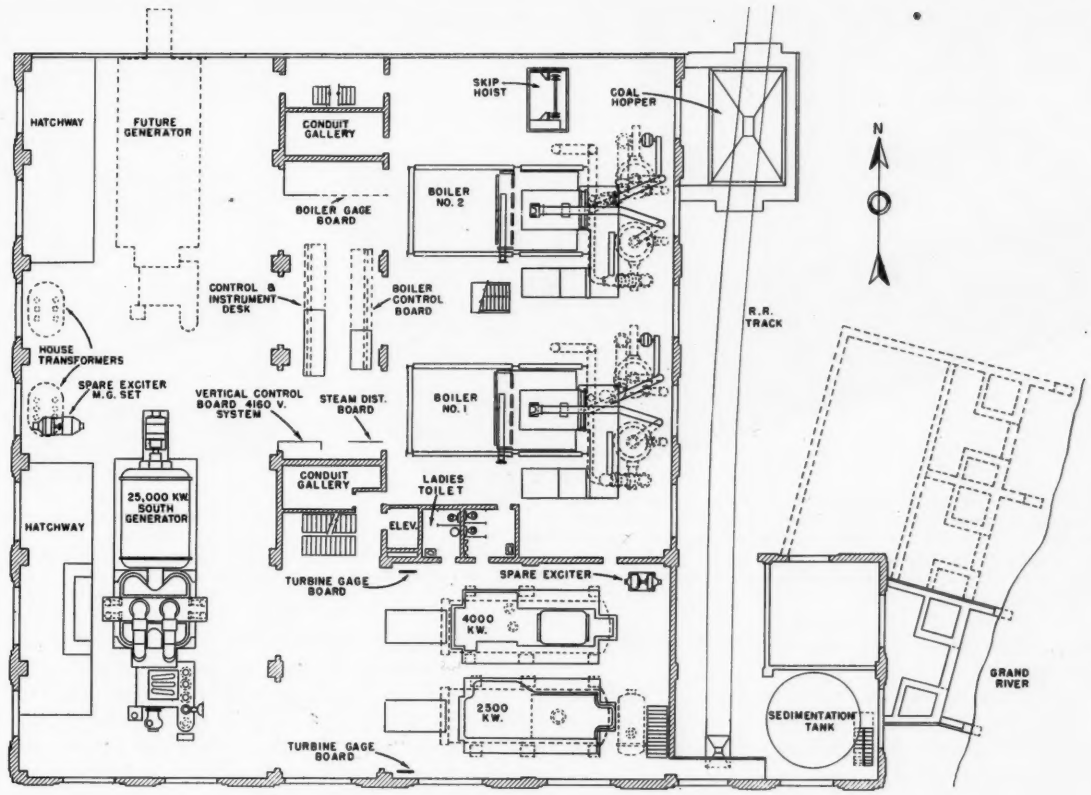


Fig. 6. Plan of the operating floor level

when additional capacity was necessary, a new station at Ottawa Street was decided upon. At this site condensing water is also taken from the Grand River, but the water supply here is augmented by that of a tributary which flows into the Grand River between Moores Park and Ottawa Street.

Designed for Unit Operation

The new station goes into operation with two 225,000 lb. per hr., 925 lb. pressure, pulverized coal fired boilers and one main turbo-generator of 25,000 kw. capacity. In addition to the main generator there are two smaller units, one a new 825 lb. pressure machine of 4000 kw. capacity and another 2500 kw. unit operating at around 175 lb. pressure and which was used in the old plant. This machine exhausts into the low pressure district heating system as will be described in further detail below. The station is designed to use a wide range of fuels, in fact any West Virginia or Ohio coal is suitable.

Although the initial installation involves two boilers, the station is designed on the unit principle of operation; one boiler and the 25,000 kw. turbine together with its associated auxiliaries operating as a single unit. The other boiler together with the 4000 kw. and 2500 kw. turbines are provided to serve the district heating system. The high pressure piping is so arranged, however, that the two boilers feed into a common high pressure header.

Control of the entire station, that is of both the steam and electrical equipment, is centralized in a single control bay located approximately in the center of the station. This bay is open to both the turbine room and the boiler room, giving the operator visual supervision of all equipment.

The boiler control board is built in the form of a conventional benchboard used for electrical control and is provided with a complete diagrammatic layout of the steam and water lines with push buttons and indicating lamps for the various motor control circuits, and the valve positions all shown in proper relationship. While this board controls the steam system it is as much an electrical control board as the main electrical control board itself since all the important steam and water valves are operated electrically.

The main electric control board is placed directly opposite the boiler control board and is also of the benchboard type. Thus a single operator virtually has control of the entire station, though all normal operation is under complete automatic control. In this respect, Ottawa Street Station goes beyond Bremo which was a highly automatic station. As already mentioned, here, as at Bremo, the air for combustion as well as the coal to the mills is measured continuously by automatic weighing and measuring equipment. At Bremo, however, it was necessary for the operator to manually adjust his fan and mill feeder speeds to maintain the proper inputs and relationships for varying loads. At Ottawa Street this relationship between fuel, air, load as well as the operation of the entire combustion equipment is controlled automatically. The operator becomes merely an observer to act only in case of emergency.

There are many other elements in the design of this station which command attention because of their

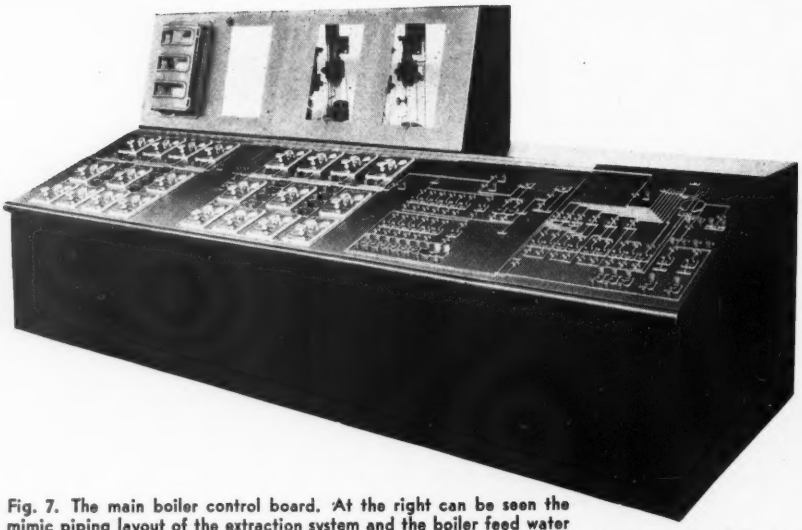


Fig. 7. The main boiler control board. At the right can be seen the mimic piping layout of the extraction system and the boiler feed water system. At the left are the four sets of controllers for the fans and feeders for each of the four burners on each boiler. Above can be seen the panels for the four Bailey 3-element vertical edgewise indicators. Only one indicator is shown mounted in position. A close-up of one of these indicators is shown in Fig. 8

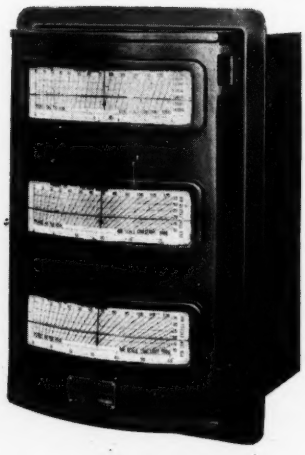


Fig. 8. A close-up of one of the 3-element indicators. These instruments show, lb. of coal per hr., primary air in lb. per hr. and secondary air in lb. per hr.

newness. Among the more important of these are the following:

1. Six-point extraction. Where there is nothing fundamentally new in 6 point extraction, it is, to our knowledge, the first time so many extraction stages have been used.

2. Automatic, pre-measurement of fuel and air to the furnaces.

3. Use of water-to-water heat exchangers in feedwater system for by-passing heat around feed pump.

4. Three stages of deaeration between hot well and boiler.

5. Re-melting fly ash from the precipitators in the furnace. Although this has been done before, the arrangement is sufficiently unusual to deserve comment.

6. Use of separate blowers to supply air to the pulverizer bearings. This is only a detail, yet it emphasizes the attention to detail that makes the entire difference between a well designed plant and one that is merely assembled.

7. Automatic temperature control of the primary air to the furnaces.

General Design

Though the location of the station in the very center of the business district was a contributing factor in the architectural design of the building, the structural characteristics were dictated largely by the type of boiler equipment used. The tall, single-pass, inclined tube boilers used and the arrangement of air heaters, precipitators and induced draft fans to form a single vertical gas passage naturally makes necessary a high building. This has a number of advantages; first, it makes possible a well lighted boiler room since the boiler room can be carried high above the level of those parts of the building housing the turbines and coal bunkers and windows can be provided on all sides. Next, it makes possible the use of very short stacks. All the draft requirements in modern power plants are fully satisfied by the forced and induced draft fans and the primary reason for the use of stacks is to discharge the waste gases high enough into the atmosphere to insure their distribution over a wide area. With equipment of the type used in this station where the gas outlet is naturally very high, the height of the stacks can be reduced to a minimum, in fact, the stacks at Ottawa Street Station extend only 12 ft. above the roof, or approximately 20 ft. above the induced draft fans.

The use of these short stacks made it possible to entirely conceal them from view by extending the parapets to approximately the same level as the top of the stacks. The result is very attractive and the building resembles anything but the conventional power plant. Indeed, it is, in our opinion, the finest example of power plant architecture that we have seen anywhere. Its well-balanced base, its correctly proportioned stepbacks, together with its pleasing symbolic color scheme all combine to produce an attractive structure fully in keeping with the office buildings, stores and hotel buildings in the vicinity.

The station is located on the west bank of the Grand River from which it obtains its supply of circulating water for the condensers. As will be noted, the turbine room forms two sides of the building. The main 25,000 kw. turbo-generator occupies the west turbine room with space for a future unit. The two smaller generating units, that is the 4000 and the 2500 kw. machines, are installed in the south turbine room. Although these are referred to here as two rooms, they form in reality a single large L-shaped turbine room.

These two rooms are served by two cranes, the west room by an 85 ton crane with a 10 ton auxiliary and the south turbine room by a 15 ton crane which was used in the old plant at this site but which was remodeled and motorized for use in the new station.

An extremely novel feature of the main turbine room is the construction of the north wall of this room. This wall can be opened up, exposing practically the entire north end of the room to the outdoors and per-

mitting the 85 ton crane to travel out over the yard outside on the extended crane rails outside the building. This is accomplished by the provision of large sliding doors in the lower part of this wall, and by hinging the entire upper section of the wall so that it can swing upward against the turbine room ceiling. The hinged section is operated by electric motors; the sliding doors by hand. The crane rails extend out into the yard a distance of some 50 ft. and are supported at the ends by a pair of vertical columns. A similar hinged wall arrangement on a smaller scale is provided in the south turbine room to give the crane there access to the railroad track on the east side of the building. Aside from the convenience, this arrangement provides in handling equipment, it permits the most excellent ventilation in summertime.

Another feature of importance in the general design of the station is the provision for running the electrical conduit up through the building. All conduit is carried vertically in two conduit galleries located so as to give most convenient access to the switchgear above. These galleries extend vertically upward through the building and intersect the floors on which the switchgear is located. They are provided with fireproof barriers to prevent fires from being carried up through them. This arrangement not only provides a neat and flexible conduit system but reduces the length of the runs to a minimum.

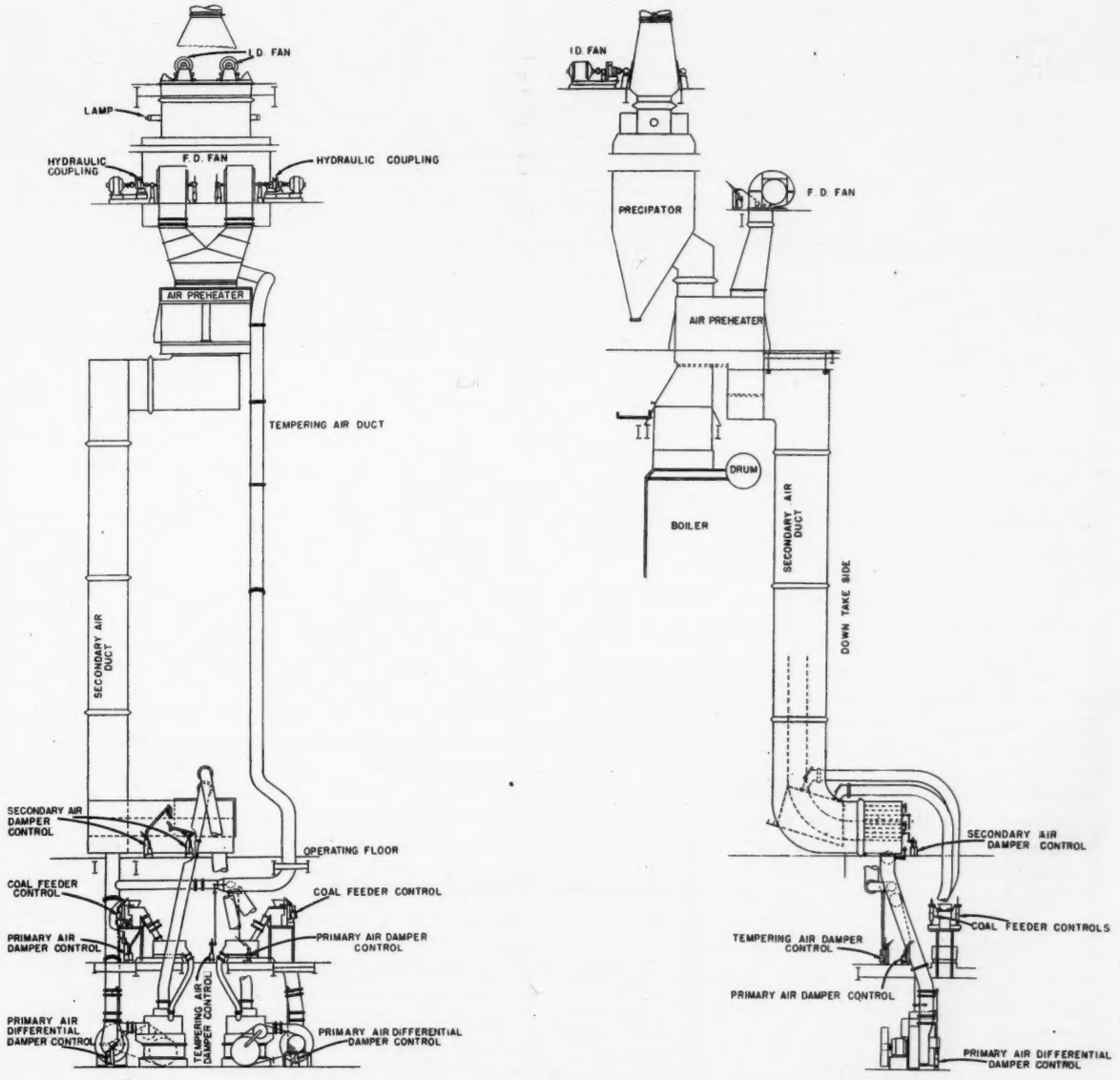
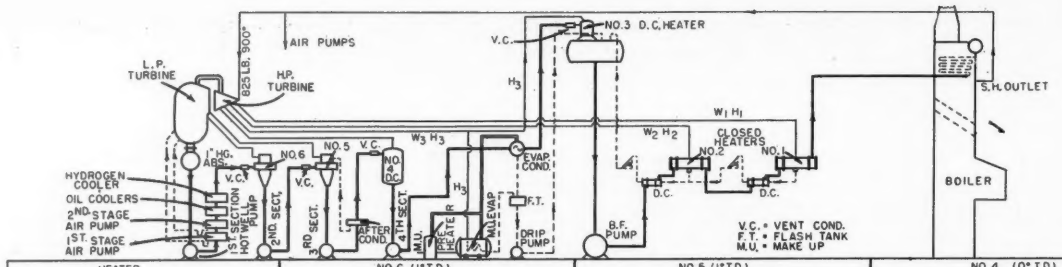


Fig. 9. Elevation, showing the draft system and the fuel feed to the boilers

All the electrical galleries are located in the center portion of the building approximately above the central control bay. As will be explained when the electrical system is described, there are two main 13,200 v. buses as well as a 4160 v. bus and a 460 v. auxiliary bus system. The location of the two 13,200 v. buses and the asso-



HEATER		NO.6 (1°T.D.)					NO.5 (1°T.D.)						NO. 4 (0° T.D.)					
1 LOAD POINT		1/4	2/4	3/4	4/4	5/4		1/4	2/4	3/4	4/4	5/4		1/4	2/4	3/4	4/4	5/4
2 PRESSURE AT NOZZLE LB./SQ.° ABS.		.59	1.04	1.50	1.99	2.53		1.91	3.27	4.72	6.25	8.03		6.15	10.9	16	21.6	28.1
3 PRESSURE MINUS 5% PIPE DROP		.56	.99	1.43	1.89	2.40		1.81	3.11	4.48	5.94	7.63		5.84	10.4	15.2	20.5	26.7
4 SAT. TEMP. AT HEATER		83	101	114	124	133		123	143	158	170	181		169	195	214	229.3	244
5 SAT. TEMP. MINUS TERM. DIFF.	FFW	——	100	113	123	132	FFW	122	142	157	169	180	FFW	169	195	214	229.3	244
6 HEAT OF LIQUID CORRES. 5 LB. DROP	h_1	——	68	80.9	90.9	99.9	h_2	90	110	125	137	148	h_3	137	163	182	197	212
7 TOTAL HEAT AT NOZZLE	H_6	1008	1002	1013	1028	1051	H_5	1059	1055	1064	1080	1104	H_4	1115	1114	1125	1143	1170
8 HEAT OF LIQUID OF STEAM AT HEATER		51	69	81.9	91.9	100.9		91	111	126	138	149		137	163	182	197	212
9 WEIGHT OF STEAM EXTRACTED	W_6	0	0	1769	4530	8240	W_5	0	2191	5483	7660	10,160	W_4	1955	4453	7177	10,220	13,970
10 REJECTION TO CONDENSER		1001	972	967	970	982												

HEATER		NO. 3 (0°T.D.)					NO. 2 (5°T.D.)						NO. 1 (5°T.D.)					
1 LOAD POINT		1/4	2/4	3/4	4/4	5/4		1/4	2/4	3/4	4/4	5/4		1/4	2/4	3/4	4/4	5/4
2 PRESSURE AT NOZZLE LB./ SQ°. ABS.		19.6	35	52	70	91		52.6	94	140	190	248		110	200	298	405	531
3 PRESSURE MINUS 5 % PIPE DROP		18.6	33	49	66	86		50	89	133	180	236		104	190	283	385	504
4 SAT TEMP AT NOZZLE		224	256	280	299	317		281	319	349	373	396		330	377.5	412	441	467.8
5 SAT TEMP MINUS TERM DIFF	FFW	224	256	280	299	317	FFW	276	314	344	368	391	FFW	325	372.5	407	436	462.8
6 HEAT OF LIQUID CORRES 5 LB. DROP	h_4	192	225	249	269	287	h_5	245	284	315	341	365	h_6	295	345	383	414	444.6
7 TOTAL HEAT AT NOZZLE	H_3	1183	1181	1194	1220	1254	H_2	1257	1257	1274	1304	1339	H_1	1322	1324	1345	1378	1411
8 HEAT OF LIQUID OF STEAM AT HEATER		192	224	249	269	287		250	290	321	346	370		301	351	388	420	450
9 WEIGHT OF STEAM EXTRACTED	W_3	2718	5635	9060	13,040	17,330	W_2	2749	5695	9575	14,090	19,580	W_1	2690	6210	10,510	15340	23,100
10 REJECTION TO CONDENSER																		

Fig. 10. Heat balance diagram and data on the extraction cycle.

ciated switchgear and the 460 v. switchgear equipment is shown on the cross section of the station in Fig. 5. There is an upper 13,200 v. bus and a lower one. These are installed on two floors one above the other, and the 460 v. buses on a floor below. Space for horizontal conduit runs is provided between floors.

The interior architectural features naturally are in keeping with the exterior. The turbine room floors are of red tile; the walls of tan glazed tile with a cream colored ceiling. The stepped windows are attractive and provide abundant illumination in day time. At night illumination is provided by special combination fluorescent and incandescent lighting units suspended from the ceiling.

On the ground floor an attractively designed air conditioned reception room is provided with air conditioned offices for the chief engineer. An Otis elevator gives convenient access to all floors of the plant. Toilet facilities for both men and women are provided.

Steam Generating Equipment

The two boilers are Babcock & Wilcox, sectional header, single pass, cross drum units of the high head type rated at 225,000 lb. of steam per hr. at a drum pressure of 950 lb. per sq. in. and with a total steam temperature of 900 deg. F. The units each have 2817 sq. ft. of heating surface, and are built with inclined tubes and a divided single pass baffle arrangement. They are provided with 2-stage water cooled furnaces, integral economizers and superheaters. The water cooled furnaces have 3411 sq. ft. of surface using both Bailey block bare tubes and stud type tubes. The furnaces are designed for continuous wet ash removal. Slag is removed from the ash hoppers hydraulically by Allen Sherman Hoff Co. Hydro-jet conveying equipment and delivered to a dehydrating type ash storage tank on the outside of the building. Measuring from the bottom of the furnace ash pits to the top of the boilers but not including the air preheaters, the boilers are 87 ft. high.

Special type cyclone steam separators are installed in the boiler drums to insure the production of dry pure steam. The superheaters are of the continuous tube type with one gas and one steam pass. They involve 6980 sq. ft. of heating surface and have a capacity range of between 125,000 and 250,000 lb. of steam per hour. The superheat temperature is regulated by 27 per cent chrome steel baffles.

The air preheaters which are Ljungstrom regenerative units are mounted directly above the boilers and the electrostatic dust precipitators are placed directly above the air heaters. The precipitators in turn discharge into the induced draft fan inlets.

There is thus a single, straight, vertical gas passage through the boiler, air heater, precipitator and induced draft fans to the stacks. The latter are of the Thermix type made by Prat-Daniel Corporation but are somewhat different from the conventional Thermix stacks in that they are square in section. As already pointed out, the stacks extend only 12 ft. above the roof.

Each of the two stacks (one for each boiler) is provided with Prat-Daniel twin induced draft fans in its base. These fans are driven by 300 hp. constant speed G.E. motors through hydraulic couplings made by the American Blower Corporation.

The induced draft fans occupy the top floor of the boiler house. The only other equipment on this floor are two large water storage tanks, one for condensate and the other for service water.

On the floor immediately below are the forced draft fans and the electrostatic precipitators. The forced draft fans which like the induced draft fans are also driven through hydraulic couplings, are Green Fuel Economizer Co. units. There are four forced draft fans,

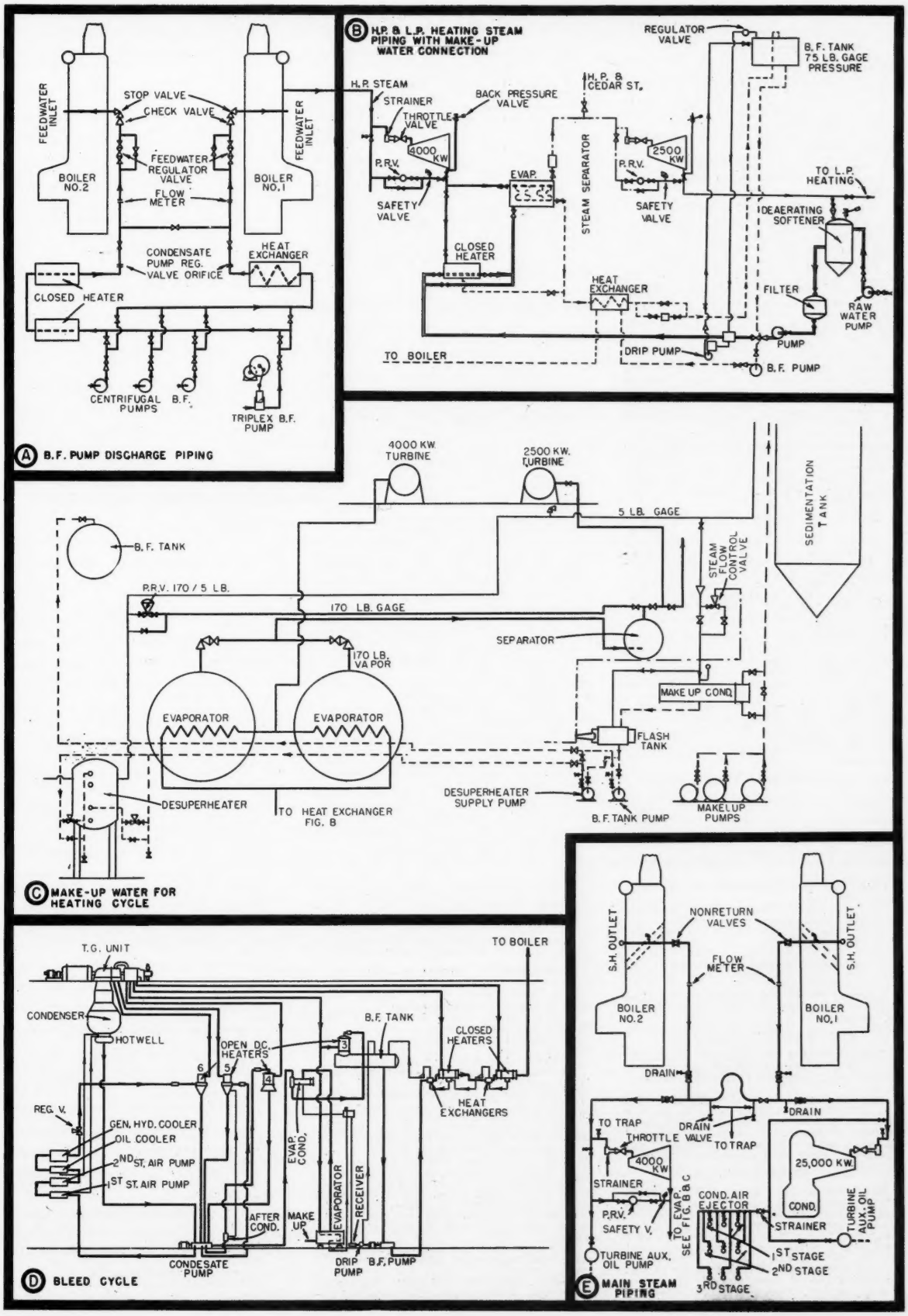

A B.F. PUMP DISCHARGE PIPING
FEEDWATER INLET
STOP VALVE
CHECK VALVE
FEEDWATER REGULATOR VALVE
FLOW METER
BOILER NO.2
BOILER NO.1
CONDENSATE PUMP REG. VALVE ORIFICE
HEAT EXCHANGER
CLOSED HEATER
CENTRIFUGAL PUMPS
B.F.
TRIPLEX B.F. PUMP
B H.P. & L.P. HEATING STEAM PIPING WITH MAKE-UP WATER CONNECTION
REGULATOR VALVE
B.F. TANK 75 LB. GAGE PRESSURE
H.P. STEAM
STRAINER
BACK PRESSURE VALVE
H.P. & CEDAR ST.
THROTTLE VALVE
4000 KW
2500 KW
P.R.V.
EVAP.
STEAM SEPARATOR
SAFETY VALVE
TO L.P. HEATING
DEAERATING SOFTENER
CLOSED HEATER
HEAT EXCHANGER
FILTER
RAW WATER PUMP
TO BOILER
DRIP PUMP
B.F. PUMP
C MAKE-UP WATER FOR HEATING CYCLE
4000 KW. TURBINE
2500 KW. TURBINE
5 LB. GAGE
SEDIMENTATION TANK
B.F. TANK
P.R.V. 170 / 5 LB.
STEAM FLOW CONTROL VALVE
170 LB. GAGE
SEPARATOR
170 LB. VAPOR
MAKE UP COND.
EVAPORATOR
EVAPORATOR
FLASH TANK
DESUPERHEATER
TO HEAT EXCHANGER FIG. B
DESUPERHEATER SUPPLY PUMP
B.F. TANK PUMP
MAKE UP PUMPS
D BLEED CYCLE
T.G. UNIT
TO BOILER
CONDENSER
HOTWELL
OPEN H.C. HEATERS
B.F. TANK
CLOSED HEATERS
HEAT EXCHANGERS
REG. V.
GEN. HYD. COOLER
OIL COOLER
2ND ST. AIR PUMP
1ST ST. AIR PUMP
EVAP. COND.
AFTER COND.
MAKE UP
EVAPORATOR
RECEIVER
CONDESATE PUMP
DRIP PUMP
B.F. PUMP
E MAIN STEAM PIPING
S.H. OUTLET
NONRETURN VALVES
FLOW METER
BOILER NO.2
BOILER NO.1
DRAIN
TO TRAP
DRAIN VALVE
THROTTLE VALVE
4000 KW
25,000 KW
STRAINER
COND. AIR EJECTOR
COND.
TURBINE AUX. OIL PUMP
P.R.V.
SAFETY V.
TO EVAP. SEE FIG. B & C
1ST STAGE
2ND STAGE
3RD STAGE
TURBINE AUX. OIL PUMP

Fig. 11

Principal Equipment at Ottawa Street Station

GENERAL

LOCATION: Lansing, Michigan.

TYPE OF PLANT: Municipally owned central station and district heating plant.

OWNERS: City of Lansing, Michigan, under the supervision of the Board of Water and Electric Light Commissioners.

CAPACITY, present: 31,500 kw. electric generating capacity.

DESIGNERS AND CONSTRUCTORS: Burns and Roe, Inc., New York, N. Y.

ARCHITECTS: Bowd-Munson Co., Lansing, Mich.

STEAM GENERATING EQUIPMENT

BOILERS: 2—Babcock & Wilcox 225,000 lb. per hr. Sectional Header cross drum high head type, 2817 sq. ft. heating surface, 950 lb. per sq. in. gage design pressure, 845 lb. per sq. in. gage at S.H. outlet, minimum operating pressure. Single setting. Number of sections (wide)—18. Nominal length of tubes—20 ft.-0 in. Inclined tube arrangement and divided single pass baffle arrangement. Water cooled furnace wall equipment of the Bailey block bare tube and stud tube types. 3411 sq. ft. heating surface. Continuous wet ash removal.

SUPERHEATERS: 2—B. & W. Continuous tube type with 1 gas and 1 steam pass. Design pressure 950 lb. per sq. in. gage. Normal steam temperature at operating pressure 900 deg. F. Capacity range at which above temperature is controlled, 125,000 to 250,000 lb. 6980 sq. ft. heating surface.

ECONOMIZERS: 2—B. & W. Steel tube, continuous tube, parallel flow arrangement. 6780 sq. ft. heating surface, 950 lb. design pressure.

PULVERIZERS: 4—B. & W. Type B, special, each with 100 hp. 440 v. G.E. induction motor.

BURNERS: 4—B. & W. Multiple intertube type. Two for each boiler.

FANS, AIR HEATERS, AND STACKS

INDUCED DRAFT FANS: 2—Prat-Daniel Twin fans, each with a 300 hp. General Electric Co. motor, with American Blower Corporation hydraulic couplings. (2 per fan).

FORCED DRAFT FANS: 4—Green Fuel Economizer Co. double inlet forced draft fans, each with a 100 hp. General Electric motor, operated with American Blower Corporation hydraulic couplings.

OIL COOLERS FOR HYDRAULIC COUPLINGS: 8—One for each of the 4 induced and forced draft fans. Ross Heater & Mfg. Co.

ELECTROSTATIC PRECIPITATING EQUIPMENT: 2—Cottrell units complete with substation. Research Corp.

AIR HEATERS: 2—Air Preheater Company Ljungstrom regenerative preheaters, type CG2X-18-½ having 58 in. elements. 42,800 sq. ft. heating surface.

STACKS: 2—Prat-Daniel Corp. Thermix type stacks.

BOILER CONTROL AND ACCESSORIES

COMBUSTION CONTROL: Bailey Meter Co. Complete combustion control systems specially designed to include automatic, pre-measurement of fuel and air.

FEEDWATER CONTROL: Bailey Meter Co. 3 element feedwater control.

SUPERHEATED STEAM TEMPERATURE CONTROL: Bailey Meter Co.

COAL AND AIR TEMPERATURE CONTROL: Bailey Meter Co.

SOOT BLOWERS: Diamond Power Specialty Corp. Revolving valve-in-head G-9-B.

DESLAGGER: 2—Diamond Power Specialty Corp. Telescopic type.

WATER COLUMNS: Diamond Power Specialty Corp. Flat glass bi-color reflecting type.

SAFETY VALVES: Consolidated, Ashcroft Hancock Co.

BLOWERS FOR PULVERIZER BEARINGS: Allen Billmyre Corp. Driven by General Electric Co. motors.

COAL AND ASH HANDLING

COAL HANDLING EQUIPMENT: Beaumont Birch Co. Consists of track hopper crusher, conveyor, skip hoist and distributing belt conveyor.

ASH SLUICING: 3—Allen-Sherman-Hoff Company, for hydraulically handling the slag from two boilers consisting of ash hoppers, hydrojet, sluiceway, horizontal type hydroseal ash pump, ash storage tank (dehydrating) and Hydroseal rubber lined recirculating pump.

TURBO-GENERATING UNITS

MAIN GENERATING UNIT: Allis-Chalmers Mfg. Company, 80 per cent P.F., 31,250 kv-a. high pressure condensing unit, 3600 r.p.m., reaction type, tandem compound, with a direct connected 125 kw., 250 v. main exciter and a 5 kw., 250 v. pilot exciter. Steam pressure at throttle, 825 lb. gage. Steam temperature, 900 deg. F. Hydrogen cooled alternator 13,800. Normal voltage—3 phase, 60 cycle.

SURFACE CONDENSER FOR MAIN TURBO-GENERATOR: C. H. Wheeler Manufacturing Corp. 2 pass condenser, 23,500 sq. ft. condensing surface, ⅞ in. O.D., No. 18 BWG Admiralty metal tubes, spring supported.

1—copper bearing steel deaerating hotwell and 1—6750 gal. cap. hotwell chamber. 1—Tubejet vacuum pump unit, 1—4 in. single stage tubejet exhauster. 2—C. H. Wheeler 30/24 vertical centrifugal single stage circulating water pumps, each with a 150 hp., 450 r.p.m. motor.

4000 KW. UNIT: Allis-Chalmers 80 per cent P.F. high pressure, 3600 r.p.m. turbo generator, 4160 v., 3 phase, 60 cycle with a 25 kw., 125 v., direct connected exciter and one generator air cooler. The unit exhausts into the evaporator condensers.

2500 KW. UNIT: Allis-Chalmers Mfg. Co. non-condensing receiving vapor at around 175 lb. pressure from the evaporator condensers and exhausting into the low pressure heating system at 5 lb. gage.

PUMPS, HEATERS AND F. W. TREATMENT

BOILER FEED PUMPS: 3—Allis-Chalmers Doubleton, double suction, 5 stage centrifugal pumps. Capacity—655 g.p.m. Driven by 600 hp. Allis-Chalmers motors.

1—Aldrich Pump Co. 4x10 in. vertical triplex pump. Capacity 60,000 g.p.h. Driven by 100 hp. Allis-Chalmers motor with American Blower Corporation hydraulic coupling.

FEEDWATER HEATER No. 1: Alco Products, Inc. feed water heater. Capacity 300,000 lb. per hr. Maximum pressure, 600 lb. per sq. in. gage hot fluid in shell with 800 deg. F. maximum temperature, and 1200 lb. per sq. in. gage cold fluid in tubes with 500 deg. F. maximum temperature, including 1 drain cooler.

FEEDWATER HEATER No. 2: Alco Products, Inc., closed heater with drain cooler.

HEAT EXCHANGER: 1—Alco Products, Inc., waterwater shell and tube type with water box. Hot fluid in shell, 250 lb. per sq. in. maximum pressure, and cold fluid in tubes, 1200 lb. per sq. in. gage maximum pressure.

MAKE-UP EVAPORATORS: 1—Alco Products, Inc. Evaporator. 1—Alco Products, Inc., Evaporator Condenser.

1—Jennings Centrifugal pump, single stage, with 7½ hp. motor drive. Nash Engineering Co.

DIRECT CONTACT HEATERS: Foster Wheeler Corporation. 2 jet type, direct contact feedwater heaters (Nos. 5 & 6). 2 rain type direct contact feed water heaters (Nos. 3 & 4). 4 tubular type vent condensers.

Actual maximum capacity water per hour:

No. 6—194,000 lb. per hr.
No. 5—201,000 lb. per hr.
No. 4—212,000 lb. per hr.
No. 3—226,000 lb. per hr.

2—Foster Wheeler condensate pumps, single suction, with 100 hp. General Electric motor, each at 1750 r.p.m.

EVAPORATORS: 2—Foster Wheeler single effect evaporator. Horizontal submerged coils, supported on internal carriage. Capacity—130,000 lb. per hr.

2—Closed type heaters.

2—Direct contact type deaerators..

Heat transfer rate: 700 B.t.u. per sq. ft. per hr.

WATER CONDITIONING: Cochrane Corp. hot lime and soda water conditioning equipment. 36,000 g.p.h. deaerating water softener, atomizing type, with a deaerating capacity of 300,000 lb. per hr. This water conditioning plant is used to soften water for the evaporator feed, for the steam heating system, consisting of:

1—Sedimentation tank 18 ft.—0 in. dia. x 36 ft.—6 in. high over straight side (arranged for 1500 g.p.h. summer capacity operating as a cold process softener.)

3—9 ft.—0 in. dia. x 5 ft.—0 in. high filters with steam agitation.

1—chemical feeding equipment consisting of:

1—chemical tank (sodium aluminate.)

1—Homestead triplex chemical pump with ¼ hp. motor.

1—Phosphate feeding equipment consisting of 1 tank and 1 Hills-McCanna duplex phosphate pump with ¾ hp. motor.

1—Lime feeder tank and 2 open impeller type chemical pumps each with 10 hp. motors.

1—Soda ash feeder, tank and 2 Ingersoll Rand S.A. pumps each with 1½ hp. motor.

1—Backwash pump with 20 hp. motor.

MISCELLANEOUS PUMPS: Dean Bros. Co. 1—3 in. service tank pump, hor. single stage, single suction with 30 hp. motor, 3750 r.p.m.

2—3 in. horizontal make-up single stage centrifugal pumps, with 15 hp., 3450 r.p.m. motors.

1—1½ in. horizontal make-up pump, single stage centrifugal pump with a 7½ hp. 3750 r.p.m. motor.

2—3 in. evaporator feed pumps, horizontal, centrifugal, 2 stage, end suction, opposed impeller type C with a 60 hp. 3450 r.p.m. motor.

1—1½ in. evaporator feed pump, horizontal, 2 stage, opp. impeller, centrifugal pump, with a 30 hp. motor.

1½—1 in. hor. single stage, centr. pump (combination receiver) and a 7½ hp. 3450 r.p.m. motor.

1—2½ in. condensate recirculating pump, horizontal single stage, 7½ hp. motor.

2—1 in. sump pumps, vertical, single stage centrifugal pump, 1 hp. motor.

1—2 in. hotwell overflow pump, horizontal, 2 stage, opp. impeller type pressure seal high vacuum condensate pump with 20 hp. motor, 3450 r.p.m.

1—1½ in. low level storage tank pump vertical, single stage, centrifugal pump with 15 hp., 3450 r.p.m. motor.

1—make-up evaporator feed pump, 1½ in. horizontal, single stage, centrifugal pump, with 7½ hp. motor.

1—receiver and condensate pump, 20 hp. motor and one 750 gal. receiver tank.

SCREEN HOUSE

WATER INTAKE SCREEN: 1—Link-Belt Company 84 in. vertical traveling refuse screen for water intake, 23,500 g.p.m. capacity, driven by a General Electric 5 hp. motor. 1—screen wash pump driven by a 10 hp. motor.

MISCELLANEOUS EQUIPMENT

CRANE 85/10 overhead traveling. Whiting Corp.

CRANE 15 T., remodeled (motorized). Whiting Corp.

CRANE DOORS: Truscon Steel Co.

BOILER CONTROL: Bailey Meter Co.

DESUPERHEATER CONTROL: Bailey Meter Co.

PIPING: National Valve & Mfg. Co.

CONDENSATE PURITY METERS: Leeds & Northrup Co.

PIPE SUPPORTS: Grinnell Co., Inc.

PIPE INSULATION: Johns-Manville Sales Corp.

SPARE EXCITER SET: Allis-Chalmers Mfg. Co.

GENERATOR AIR COOLER: Griscom-Russell Co.

460 V. SWITCHREAR: General Electric Co.

13.2 KV. AND 4160 V. SWITCHGEAR: General Electric Co.

PYRANOL TRANSFORMERS FOR STATION SERVICE: General Electric Co.

MAIN ELECTRIC CONTROL BOARD (Benchboard 13.2 kv. system): General Electric Co.

VERTICAL CONTROL BOARD (4160 v. System): General Electric Co.

ROOF & TEMPORARY SIDING: Porete Mfg. Co.

SASH FOR WINDOWS: Vento Steel Products Co.

BRONZE DOOR: Ellison Bronze Co.

TANKS, OIL, WATER: Buffalo Tank Corp.

BOILER FEED LINE STOP AND CHECK VALVES: The Edward Valve & Mfg. Co., Inc.

FORGED STEEL STOP VALVES: The Edward Valve & Mfg. Co, Inc.

FORGED STEEL CHECK VAIVES: The Edward Valve & Mfg. Co., Inc.

CAST STEEL STOP VALVES: The Edward Valve & Mfg. Co., Inc.

MOTOR OPERATED VALVES: Chapman Valve & Mfg. Co.

AIR COMPRESSOR: Sullivan Machinery Co.

TANKS, FUEL OIL STORAGE: Graver Tank & Mfg. Co., Inc.

INSULATION (Pipe Covering): Johns-Manville Sales Corp.

HEAT DISTRIBUTION PANEL with Crosby, Brown & Bristol Instruments. Energy Control Co.

HYDRAULIC COUPLINGS: American Blower Corp.

EVAPORATOR CONDENSER for Heating Cycle. Ross Heater & Mfg. Co.

COOLING WATER CONTROL SYSTEM: Hagan Corp.

SANACOUSTIC CEILING: Johns-Manville Sales Corp.

STRUCTURAL STEEL: R. C. Mahon Co.

REINFORCING STEEL: Truscon Steel Co.

TURNTABLE: American Bridge Co.

MISCELLANEOUS STEEL: Allied Steel and Conveyor Co.

CHLORINATING SYSTEM: Wallace & Tiernan Co., Inc.

DESLAGGER BOOSTER PUMPS: Westco Pump Corp.

CIRCULATING WATER PUMPS: C. H. Wheeler Mfg. Co.

GLASS BLOCKS: Pittsburgh Corning Corp.

GRATING, GABY COPPER QUAD: Standard Steel Spring Co.

CONTRACTORS

EXCAVATION AND FOUNDATIONS: H. G. Christman-Lansing Co.

SUPERSTRUCTURE: Reniger Construction Co.

DISCHARGE TUNNEL: Fry & Kain, Inc.

TRACKWORK: Jarvis Eng. Co.

ELECTRICAL CONTRACTOR: Hatzel & Buehler, Inc.

INSULATION (Pipe): Murphy Supply Co.

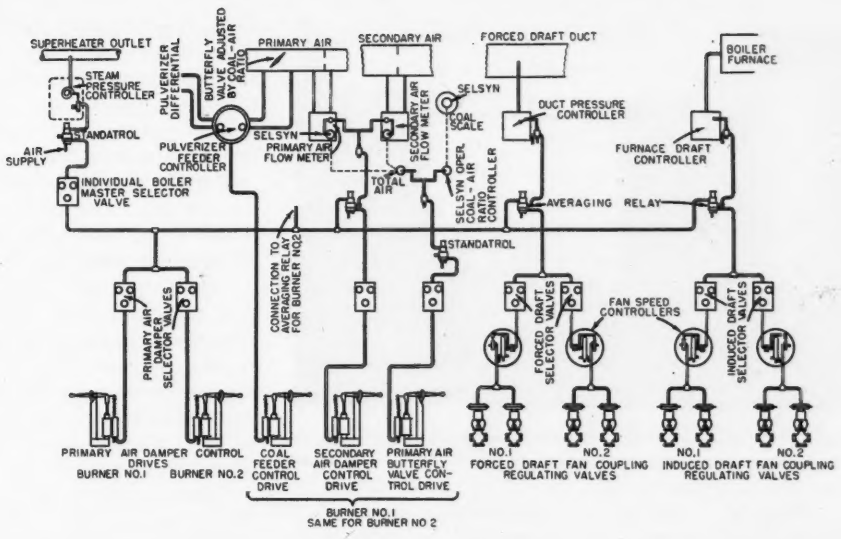


Fig. 12. Diagrammatic layout of the special Bailey Combustion Control System

one delivering air to each of the four pulverizers. The forced draft fans are driven by 100 hp. constant speed General Electric motors.

The forced draft fans discharge downward, directly into the air preheaters on the floor below. A portion of the forced draft supply is tapped off at a point just above the air preheater; this being used as tempering air for controlling the temperature of the air to the pulverizers. This is carried down through separate ducts. Heated air from the air heaters passes downward through insulated vertical ducts to the secondary air chambers surrounding the burners where a portion of it is drawn off for use as primary air.

Details of the Draft System

The air supply system, may be quite easily understood by reference to Fig. 9 which shows the details of the draft system. Secondary air from the air heaters passes downward through the secondary air ducts to the air chambers at the burner level where it is fed to the furnace under the control of the secondary air dampers. The primary air is taken from the lower part of the secondary air duct by a duct leading to the primary air fan. The tempering air duct mentioned above is also connected with this primary air duct. Both the supply of tempering air and the primary air to the fans is controlled by separate sets of dampers all under automatic control.

The air supply to the burners is measured by Bailey air meters. These meters operate upon a pressure differential across a rectangular orifice in the air ducts, and thus provide a continuous indication of the amount of air being delivering to the furnaces. The air being measured is maintained at constant pressure and the measurement is compensated for temperature thereby converting a volume measurement to a true weight measurement.

The coal to the pulverizers is also measured continuously and automatically. Raw coal from the overhead bunkers flows by gravity to motor driven feeders under automatic control and then to Bailey automatic weighing machines which provide a continuous indication of the quantity of coal passing through them. From these weighing machines the coal flows by gravity into the pulverizing mills on the floor below. The actual arrangement of this equipment is clearly shown in Fig. 9. The quantities of measured coal and air are indicated by meters on the boiler control board in the central control room.

As will be noted, there are four pulverizers, each with its own feeder and weighing equipment. Two mills supply one boiler. The mills are Babcock and Wilcox Co. units, each with its own primary air fan and driven by a 100 hp., 440 v. General Electric motor. The motor is mounted on the fan shaft which operates at 1765 r.p.m. but the mill is driven at reduced speed through a V-belt drive. An interesting feature about the pulverizing mills is that their bearings are kept cool and free from dust by a separate air supply. This consists of two Allen and Billmyer Co. blowers, motor driven, and supplying air at a pressure of about 1 lb.

The raw coal handling system is simple. Coal delivered by railroad cars is dumped into a track hopper and by a short flight conveyor is delivered to a crusher. From the crusher it falls into the bucket of a vertical skip hoist which elevates it to the top of the coal bunker where it is distributed by a distributing belt conveyor.

The coal bunker which is of structural steel and the coal handling equipment are sealed off completely from the rest of the boiler house, a feature which contributes greatly to the cleanliness of the plant.

The method of disposing the fly ash which collects in the precipitator hoppers is simple and effective. This dust is fed into a 6 in. line of flexible armored tubing which connects into the lower side wall of the primary furnace, that is at a point directly below the burners. Here a motor driven ram, similar to that in an underfeed stoker retort, forces the ash into the furnace where it is liquefied by the heat of the furnace and thus falls into the ash pit. The dust is removed from the precipitator hoppers by a motor driven spiral feeder and motor driven vibrators just above the feeders keep the dust from packing and bridging. This vibrator consists of an off-balance motor driven flywheel operating through a diaphragm fitted into the wall of the dust hopper.

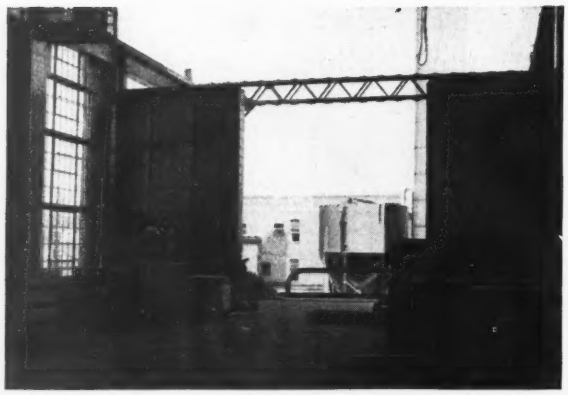


Fig. 13. Looking north in the turbine room, showing how practically the entire north end of the room can be opened to the atmosphere

Diamond revolving valve in the head soot blowers are provided as well as a telescopic deslagger. The soot blowers are operated at a pressure of about 400 lb. through reducing valves mounted on the sides of the boilers.

There are two burners per boiler. These are B. & W. multiple intertube type burners and, as shown on the elevation, are set in the top of the primary furnace chamber and are directed downward at a slight angle. They are enclosed in insulated air chambers through which the secondary air is delivered in measured amount. The automatic combustion control system automatically compensates for varying quantities of air and coal but the total remains constant for given loads. With this system it is expected that the excess air at the burner tips will not exceed 12 per cent at all loads.

Six Point Extraction

The feedwater heating system, involving six point extraction, can readily be understood from the simplified diagram in Fig. 11D. As in the case of Bremo Station, here too a multiple section condensate pump is used. This pump removes the condensate from the condenser hotwell and delivers it, successively, through three direct contact open feedwater heaters and finally through the evaporator condenser and a fourth direct contact heater, to the boiler feed tank. This part of the system, as will be noted, involves the generator air and oil coolers and the condenser air pumps. Makeup from the evaporator is also delivered into the boiler feed tank. The direct contact heaters are of two types; heaters Nos. 5 and 6 are jet type heaters while Nos. 3 and 4 are rain type heaters. Heater No. 3, as will be noted, is mounted directly on the boiler feed tank.

The boiler feed pumps take suction from the boiler feed tank and force the water through two high pressure closed heaters and then to the economizer section of the boilers. The drips from the high pressure heaters are cascaded through two small closed heaters and delivered to the boiler feed tank. This arrangement is clearly shown on the heat balance diagram, Fig. 10.

This describes the feedwater arrangement for the 25,000 kw. turbine cycle. In the case of the 4000 and 2500 kw. machines the arrangement is different. From the boiler feed pumps the feedwater passes through a water-to-water heat exchanger and then directly to the boilers. This water-to-water heat exchanger exchanges heat from the evaporator drains (coils) with the discharge of the boiler feed pumps. The evaporators referred to here are the 130,000 lb. capacity units receiving steam from the 4000 kw. turbine. With this arrangement, it will be noted, the heat derived from the evaporator drain by-passes the feed pumps. The water being delivered to the suction side of the feed pump while the heat is delivered to the discharge side of the feed pumps. This arrangement is decidedly unusual.

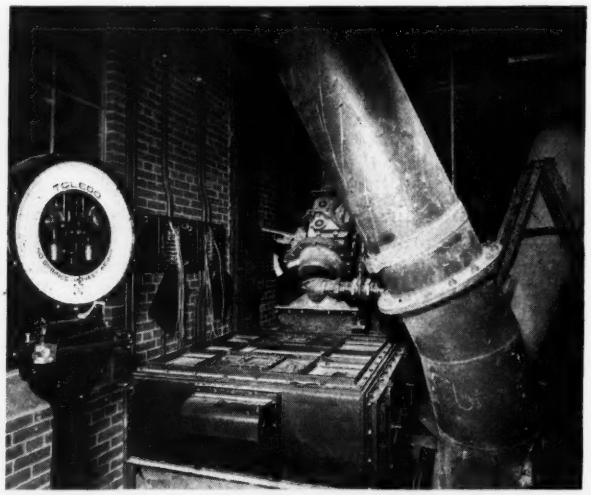


Fig. 15. One of the continuous, automatic coal scales. Coal to the pulverizer below is weighed continuously and the readings transmitted to the control room electrically

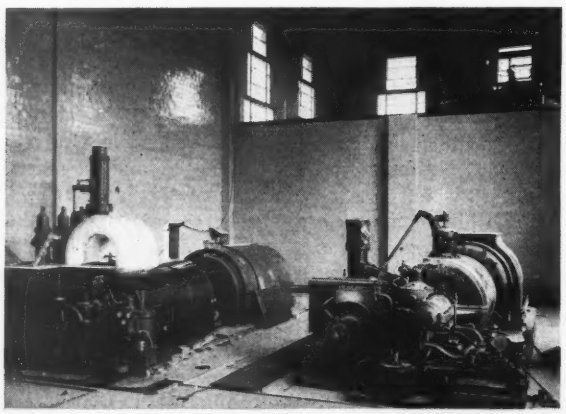


Fig. 14. The two 4160 v. turbo-generators. The unit at the left is the 825 lb. 4000 kw. machine exhausting at about 200 lb. into an evaporator below. The unit at the right is a 2500 kw. machine taking vapor at about 175 lb. from the evaporator below and exhausting into the low pressure heating system at 5 lb

The multiple section condensate pumps are two in number. They are Foster Wheeler Corp. 4 section units, equipped with Kingsbury thrust bearings, driven by 100 hp. General Electric motors.

Four boiler feed pumps are provided, three of which are 5 stage Allis-Chalmers centrifugal pumps rated at

655 g.p.m. against a 2690 ft. head, and driven by 600 hp. Allis-Chalmers motors while the fourth unit is a special reciprocating pump used only for low loads. This machine is an Aldrich Pump Co. triplex pump, motor driven through an American Blower Co. hydraulic coupling.

Steam conditions at the turbine throttle are 825 lb. pressure, 900 deg. F. Steam purity is checked continuously by Leeds and Northrup condensate purity meters. By the use of these meters it is expected to hold the resistance of the condensate to 3½ or 4 million ohms per cu. in.

The main steam piping system is shown diagrammatically in Fig. 11E. As will be noted, the two boilers feed into a single main steam header one end of which supplies the 25,000 kw. turbine and the other end the 4000 kw. unit and the heating system. All joints in the high pressure piping system are welded, and heat treated. Large expansion loops are provided and the piping suspended by means of Grinnell constant support hangers. All the main valves in the high pressure lines are Chapman motor operated valves.

Generating Units

The main generating unit is an 825 lb. pressure, 900 deg. F., 3600 r.p.m. tandem compound, Allis-Chalmers machine driving a 31,250 kv-a., 13,800 v., 3 phase, 60 cycle hydrogen cooled generator. Excitation is furnished by a 125 kw. exciter and 5 kw. pilot exciter, both geared to the main unit to operate at 1500 r.p.m.

This unit exhausts into a 23,500 sq. ft. C. H. Wheeler surface condenser, spring supported and provided with a Tubejet vacuum pump unit and a 4 in. single stage Tubejet exhauster. The two circulating pumps are C. H. Wheeler 30/24 vertical, centrifugal, single stage pumps, each driven by a 150 hp., 450 r.p.m. motor. These pumps are installed below the river level at a point close to the intake.

The 4000 kw. generating unit is also an 825 lb., 900 deg. F., 3600 r.p.m. Allis-Chalmers machine but this unit drives a 4160 v. generator. This turbine exhausts into two 130,000 lb. capacity Foster Wheeler evaporators. The exhaust pressure varies between 230 and 197 lb. Vapor produced in the evaporator at about 175 lb. pressure supplies the 2500 kw. turbo-generator and also the high pressure district heating system. An 8 in. booster line some 8000 ft. long connects with Moores Park Station at this pressure.

Exhaust from the 2500 kw. turbine at 5 lb. pressure feeds the low pressure heating system and the Cochrane hot process softener which supplies the water for the evaporators.

This then gives a picture of the method of producing steam for both the high (175 lb.) and low (5 lb.) pressure heating systems. In case the 4000 kw. turbine is unable to satisfy the steam demands on the heating system, 850 lb. steam can be by-passed to the evaporator inlet through a reducing valve.

River water is used for the heating cycle. This is softened in the Cochrane hot process softener. then strained and filtered in three 115,000 g.p.h. Cochrane sand filters. From the softener it is delivered to the two evaporators.

Centralized Control

The centralized control room, as already pointed out, occupies a central location on the operating floor and is open to both turbine and boiler rooms. In addition to the two benchboards, one for the boiler control equipment and the other for the electrical control circuits, there are vertical panels carrying indicating and recording instruments of various kinds.

The boiler control board is perhaps the most interesting thing in the control room. Its face carries a complete diagram of the high pressure steam and water lines with push buttons and indicating lamps for the various motor controls and electrically operated valves shown in proper position. The steam and water lines are represented by copper, brass and chromium plated bars. The boilers and fans, as well as the turbine and condenser and all the heaters, are likewise shown on this panel. The entire extraction heating system is shown in considerable detail.

Immediately above the inclined panel carrying this equipment are the meters showing the quantities of coal and air being delivered to the pulverizers. These meters are so designed and so placed that for given loads their pointers are brought into coincidence. The entire control is of course automatic but in case of emergency it can be converted to manual operation and the control of all fans and pumps as well as valves effected manually from this board. All instrument readings are transmitted electrically by the Selsyn system of remote indication.

The combustion control system is that of the Bailey Meter Co. but it has been modified to suit the particular requirements of this station. The pre-measurement of fuel and air, for example, is quite unusual and not normally a part of conventional combustion control systems.

The electrical control board which is also a benchboard is located opposite the boiler control board and is also provided with a complete diagram in mimic bus bar form of the electrical connections.

Electrical Features

Current is transmitted to substations at various load centers in the city at the voltage at which it is generated, that is 13,200. The main generator feeds into two 13,200 v. buses, known as the upper and the lower bus because they are installed on two different floors, one above the other. Each of these two buses consists of two sections which may be sectionalized if necessary. Provision for extending these buses with the future growth of the station is provided as shown in the single line wiring diagram. In addition to the direct connected exciters, already referred to in the description of the main turbo-generator, a 125 kw. spare exciter is provided as shown. This spare will also serve future generators by extending the exciter bus.

Station auxiliaries are supplied from two 460 v. house service buses, one known as the west bus and the other the east bus. The west bus is supplied directly from the 13,200 v. buses through a 3000 kv-a. 13,200/480 v. house service transformer. The east bus is supplied from the 4160 v. bus, through a similar house service transformer but wound for a 4160/480 v. ratio.

The 4160 v. bus, which is divided into two sections,

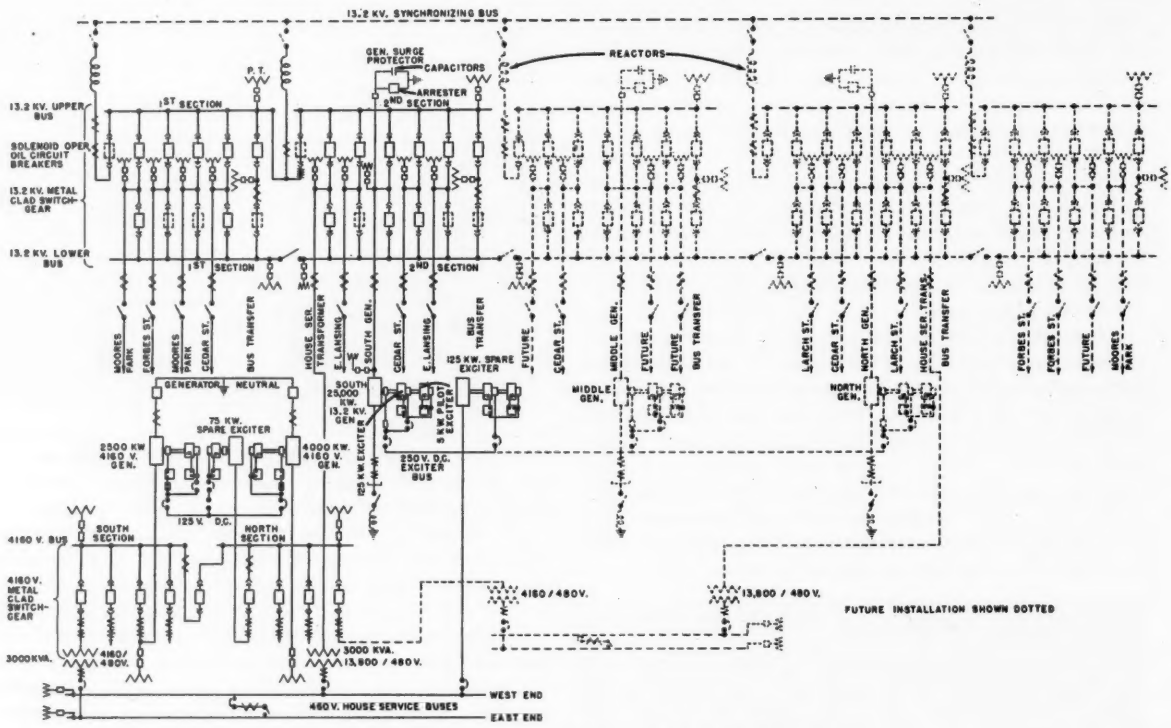


Fig. 16. Single line wiring diagram of the electrical system

a north section and a south section, receives its power from the two small turbo-generator units. The 2500 kw. machine connects directly with the south section of the 4160 v. bus and the 4000 kw. unit with the north section. The two sections of the 4160 v. bus can, however, be connected so the two small units normally operate in parallel.

The electrical system may be clearly understood from the single line wiring diagram shown in Fig. 16, which shows provisions for future extensions to the system as well as present connections. It will be noted from this that provision is made for the installation of a future 13,200 v. synchronizing bus, through which the various main bus sections will be paralleled through reactors. The floor immediately above the upper 13,200 v. bus floor will accommodate these reactors.

All switchgear is General Electric, metal clad, using solenoid operated oil circuit breakers on the 4160 v. as well as the 13,200 v. circuits. The principal circuit breakers are remote controlled from the central control room. The main 13,200 v. control board is a bench-board while the 4160 v. circuits are controlled from a vertical board.

Current for station lighting and small motors is supplied by two 75 kv-a., 480/120 v. transformers.

The two 300 kv-a. station transformers are General Electric Pyranol units, mounted on trucks on rails on the condenser floor.

Conclusion

In concluding this account of this most interesting station we are conscious of having omitted mention of innumerable small but interesting details, all of which combine to produce the highly coordinated whole that this station represents. Such things as an extremely unusual turntable for routing railroad cars into the plant, the easily removable sections of flooring in the turbine room to provide access to the equipment below, the provision for recirculating condensate through the hydrogen coolers on the generator can only be mentioned in passing, yet each is of considerable importance. Features such as the entire isolation of the turbine foundations from the turbine room floor and the use of steel foundations on the small turbines to provide space for the evaporators, though not unusual, reflect the care with which detail of design has been attended to. As regards the new features, those specifically listed at the beginning of this description, though they may be unique, none of them lack justification from an engineering or economic standpoint. All of them in fact have their origin in the operating experience of the past.

It is to the credit of the Board of Water and Electric Light Commissioners of the City of Lansing not only that they had the confidence and foresight to authorize the construction of this outstanding plant but that it was built without any federal or other aid.

It was financed from accumulated depreciation reserve and accumulated surplus without the issuance of any bonds or obligations. By virtue of its long experience in the operation of a power system under the able direction of Otto E. Eckert, its general manager, the Water and Light Board was fully familiar with the problems involved in building a new plant and the members made a thorough investigation of plants throughout the country before retaining Burns and Roe, Inc., of New York to design and construct this station. All design and construction was carried out under the personal supervision of R. C. Roe of Burns and Roe. Bowd-Munson Co. of Lansing were the architects.

Coöperative Management

Its Use in Consolidating Organization Activity and Morale

WITH GROWTH of industry and development of corporations, one-man management is no longer possible or desirable. No one man can know all employes or keep track of and decide wisely on all problems of production, distribution and relations with workers and the public. To bring together the information, essential to intelligent management, requires coöperation of those who have direct contact with workers in the plant and the distribution system, as well as with customers, so that the interests of all may be considered. The executives will naturally have in mind the investors and the public at large. But management has the duty to secure fair consideration of all whose interests are affected by the industry and a fair distribution of the income from operation of the organization.

If executives are acutely and interestedly conscious of their duties, the desired results may be accomplished by frequent consultation with workers in production and distribution, but, in many organizations, it has been found more effective to create a management board in which workers have direct participation, either with power to act or to make recommendations to those responsible for management.

Such a board may consider working conditions, possible rates of payment to workers, taking into account competitive conditions as to sales, prices and reasonable return to investors, methods of increasing sales and income, relations with employes and with the community. The important objective is to secure coöperative effort of the entire organization to advance the welfare of its members, and of the industry, and to secure approval of customers and the public.

To secure coöperation within the organization, workers must have confidence in the good will of management and its policies. This involves an understanding of the problems of management, in finances and competition. Representatives of workers on the management board will gain such an understanding and can transmit it to the members of the organiztaion. Through these representatives, workers have a direct approach to management for presenting their views as to working conditions and wages, also to suggest improvements in products and methods. Properly carried out, such management can create the feeling of members in an organization working for a common end.

Organizations of such a management board and details of its operation will, of course, vary with the size of the organization, its product and local conditions. The fundamentals are such participation of workers as will give them, as well as investors, understanding of costs, possible income, limitations of operation and the effect of workers' activities on success of the business. The spirit of "we" in the organization is all important.

Some management board methods which have worked satisfactorily are as follows: An Advisory Committee deals with workers' desires and complaints. It consists of a representative for each 50 workers in a department, or for each department which has less than 50 workers. The board meets monthly, discusses all phases of the business and reports to the workers. Any worker can take up with his representative any matter concerning his welfare, wages, hours, working conditions, and the representative can carry the matter to management—up to the highest executive if that is considered necessary.

To give a feeling of confidence, new employes are taken to their foremen and to their representatives on the board and introduced personally, and these in turn are expected to get the new men acquainted with their fellow workers. Each man's abilities and progress are recorded by his immediate superior, these records being reviewed once a year with a view to promotions or to changes in jobs where a man seems better fitted for work other than what he has been doing.

In another company, management problems are divided among four boards. One, a supervising board, deals with general policies and passes upon the recommendations of the other three, generally approving them. A second board represents office workers, dealing with problems of administration and management. A third board, for plant workers, takes up relations between company and workers, working conditions, workers' suggestions and views. The fourth board, representing salesmen and territorial managers, considers distribution problems and customers requirements. Each board meets at such intervals as seems desirable.

Most extensive participation has been assigned by another firm which gives the "Workers Coöperative Association" authority to establish or change rules as to discipline, working conditions, relations of workers to the company or other matters except the business policies of the company. An elected arbitration board, having no executive management representative, governs, discharges and passes on workers' requests and grievances. The association has a full time secretary elected by the council with salary and expenses paid by the company. Extensive welfare activities, such as emergency fund, men's, women's and girl's clubs, group insurance, are carried on and workers are reasonably satisfied with conditions. The plan does not seem to meet the requirements for imparting better understanding of general organization problems or for dealing with union representatives, but might be extended to do so.

It would seem that a management board should include representatives of workers, minor executives, salesmen, financial management. Even a confirmed grouch from among the workers may well be included to uncover points which may cause friction in the organization. Any officials on the board should have a sympathetic interest in the workers' view point.

Reports to workers on the deliberations and decisions of the board should, of course, be in the name of all the board members. It has been found worth while in many cases that a copy of such reports be distributed to each worker of the organization rather than posted as a bulletin, to ensure that the activities of the board come to the attention of everybody in the organization.

Financial Economy and By-Product Power

By James O. G. Gibbons

IN PLANTS which can use a quantity of comparatively low pressure steam, the possibility of generating by-product power, is of considerable interest, as where all, or the greater part of the exhaust steam from the engines or turbines can be used, this provides an exceedingly economical source of power. The owner is, of course, interested in financial, rather than thermal economy, so we will try to look at the problem from the point of view of the accountant, rather than from that of the engineer.

If we have a simple engine, operating at 100 lb. ga. pressure, or 115 lb. abs., with zero pounds (15 lb. abs.) back pressure, which we will assume for simplicity, although in practice we shall probably have at least 2 lb. back pressure, and the engine takes 40 lb. of dry saturated steam per indicated horsepower per hr. The total heat (Enthalpy) of the steam will be nearly 1189 B.t.u. per lb., which multiplied by 40, gives 47,560 as the total number of B.t.u., supplied to the engine per hr. per i.hp.

There will be some heat in the water supply from which the boiler is fed, and we will assume that the temperature of the water is 50 deg. F., so it has 50 B.t.u. in each pound, or 2000 B.t.u., in 40 lb. Here is an important point to keep in mind; these B.t.u., do not cost us anything, all others do.

Financial B.t.u.

We can, it is true, get a whole lot of B.t.u. for one cent, but small as it may be, each B.t.u., is equivalent to a definite sum of money, and we are going to treat it as such. We will call these B.t.u. which represent money, "Financial B.t.u.", or F. B.t.u. We will now debit our engine with 47,560 B.t.u. and credit it with 2000 B.t.u. which were in the water, leaving 45,560 F.B.t.u. standing against the engine.

In the first instance, we will assume that we cannot use any of the exhaust from the engine, except that we will take just enough of it to raise the boiler feedwater from 50 to 200 deg. F. For this we shall need 40 times 150, or 6000 B.t.u., with which we will credit the engine, leaving a net balance of 39,560 F. B.t.u. so we can say that the cost of one i.hp. is 39,560 F. B.t.u. As there are 2545 B.t.u. in one i.hp. our financial efficiency will be 2545/39,560, or nearly 6.5 per cent.

We will now see what would happen if we could make use of all the exhaust steam for heating and other purposes. The total number of B.t.u. in the live steam was 1189 per lb., or a total of 47.560. From this we shall have to take 2545, for one i.hp. generated, leaving 45.015, as the total heat in the exhaust mixture, or 45015/40 = nearly 1125 B.t.u., per pound.

At 15 lb. abs. pressure, the heat of the liquid is 181 B.t.u. so we have 1125 — 181, or 944 B.t.u., latent heat, but, dry steam requires 967.7, so 944/967.7, or 97.14 per cent is dry steam, containing $0.9714 \times 1150.7 \times 40$, or 44,712 B.t.u. To produce this in a boiler, would cost us $44712-(0.9714 \times 40 \times 50)$ or 42,769 F. B.t.u., for which we can give credit to the engine.

The engine has charged against it 45,560 F. B.t.u., and if we subtract 42,769 from this, we shall get, as the cost of one i.hp., 2791 F. B.t.u. Therefore 2545/2791 is 91.2 per cent, the financial efficiency of the engine.

If Only Part of the Exhaust Is Used

It may be well to note here that mere reduction in pressure, such as through a reducing valve, does not entail any appreciable loss of B.t.u., and we obtain from the above an efficiency which cannot be approached by any direct method of power production.

Let us now consider what would happen if we could only use half the exhaust, and had to waste the rest. As before, we will debit the engine with 45,560 F. B.t.u. and then credit it with half of 42,769, or 21,385 F. B.t.u. which will leave as the cost of one i.hp. 24,175 F. B.t.u. Thus 2425/24,175 is about 10½ per cent the financial efficiency of the engine, is not so very good, but we can see that it would be very profitable to generate at least half our power, even if we bought the rest. There may be better methods of solving this problem, however. Suppose we try a uniflow engine taking 25 lb. of steam per i.hp.

In this case we must charge the engine with 25 (1189—50) or 28,475 F. B.t.u. and we can credit it with 21,385 F. B.t.u., making the cost of one i.hp. 7079 F. B.t.u. Thus 2545/7079 gives a financial efficiency of 36 per cent, which is very good.

If we used all the steam from the more efficient engine, we should of course as before, debit the engine with 28,475 F. B.t.u. The total heat in the live steam was 1189×25, or 29,725, from which we must take 2545, leaving 27,180 B.t.u. in the exhaust mixture. This is 1087 B.t.u. per lb.

The heat of the liquid is 181 B.t.u., so we have 906 left for latent heat, but dry steam requires 967.7, so 93.4 per cent is dry steam containing $0.934 \times 1150,7 \times 25$ or 26,869 B.t.u. To produce this in a boiler, would cost us $26,869-(0.934 \times 25 \times 50)$ or 25,701 F. B.t.u., which we can deduct from 28,475, making the cost of one i.hp. 2774 F. B.t.u. As 2545/2774 is about 92 per cent, it shows that when we can use all the exhaust steam, we cannot afford to spend money on an efficient engine.

In process work, we often require steam considerably above atmospheric pressure, let us see what would happen with exhaust at 15 lb. ga., or 30 lb. abs., using the engine which previously took 40 lb. of steam, per i.hp. We will assume that we have been operating with 25 per cent cut off, and if we refer to the accompanying curve, we shall see that the mean absolute pressure, with 115 lb. abs. initial pressure, would be about 0.6×115, or 69 lb.

To get the same power with 15 lb. more back pressure, we shall have an average pressure of 84 lb., which is 84/115, or about 0.73 of the initial pressure, and we can see from the curve that this requires a cut off of about 0.36, instead of 0.25, which we had before.

The amount of steam is proportional to the cut off, and our 40 lb. will become 36 divided by 25 × 40, or 57.6 per i.h.p. We have to supply 57.6 × 1189, or 68,486, instead of 47,560 B.t.u., per i.hp. and our F. B.t.u. will be 68486—(50 × 57.6) or 65,606 F. B.t.u.

It is clear that we have lowered the economy of the engine, but what will happen if we can use all the exhaust steam. There remains in the exhaust 68,486—2545, or 65,941 B.t.u., which is equal to about 1145 B.t.u., per lb. At 30 lb. abs., the heat of the liquid is 218.8, the latent heat 945.1 and the total heat 1163.9, B.t.u. per lb. If we take 218.8 from 1145 we get 926, for the latent heat in the mixture. As dry steam requires 945.1 B.t.u., 926/945.1, or 98 per cent is dry steam, containing 1164 B.t.u. per lb. Thus we have 0.98 × 1164 or 1141 B.t.u. per lb., which multiplied by 57.6, gives us 65,722 B.t.u.

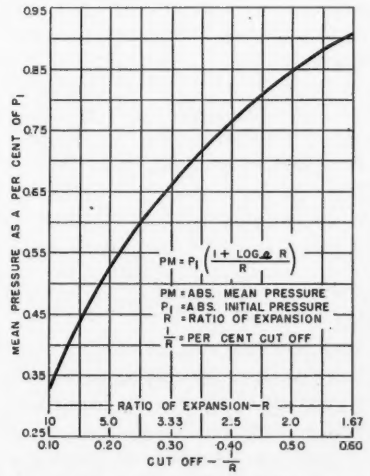
To produce this in a boiler we shall have to produce 65,722—(0.98 × 57.6 × 50) or 62,900 F. B.t.u., which we can deduct from the 65,606 F. B.t.u. charged to the engine, leaving 2706 F. B.t.u. as the cost of one i.hp. This shows that back pressure will not hurt our financial economy, if we can use all the exhaust steam.

If all the exhaust steam cannot be used, it is generally more economical to raise the boiler pressure, if possible, instead of increasing the cut off, as for instance, to raise it so that the average engine pressure will be 84, instead of 69 lb. abs.

We have seen from the curve, that at ¼ cut off, approximately 0.6 pounds average requires one pound initial pressure, so 84 lb. would require about 140 lb. abs. We should then take the same volume of steam, giving us nearly the same economy as we had with no back pressure, except that there would be a slight loss, due to the greater density of the steam.

As where the greater part of the exhaust steam can be used, the efficiency of the engine is not of importance, it is often economical to install high speed turbines, which have a high steam rate, but which are low in first cost, and supply steam free from oil. In general, the method of figuring the economy of by-product power with turbines, is similar to that described for engines.

It should be noted that the results given are theoretical, and are for indicated and not brake horsepower. In practice there will be certain losses which have not been considered here, but they will not seriously affect the comparative results, the assumed steam rates, are of course high, except for small units.



Relation of mean pressure as a function of initial pressure and cut-off

So You're Against Capital?

By G. Campbell Kohlar

TO THE Businessman Capital means one thing; to the Economist it means something else; but to most of us it is just a seven letter word beginning with "C." Capital is a mighty important consideration in the industrial and economic life of today. It affects not only the banker and the stock promoter but everyone who works for a living. C. W. Kellogg in his very interesting discussion in the January issue mixed the two major conceptions of capital so thoroughly that, like two dogs in fight, it is almost impossible to tell which tail goes with which head.

To the businessman, capital means the total securities or representative values issued by a corporation against its actual property. This includes stocks, bonds, funded debt, and so on. It has been my experience, however, that the great majority of engineers and plant workers never in a single lifetime acquire sufficient first hand knowledge of this conception of capital to make it a matter of even academic importance.

The economist's conception of capital is something different, and strangely enough, it is this conception that is the important one. To the economist, capital means those instruments of Society which are capable of producing material wealth, that is, usable goods, more capital, or income. The business idea is really a derived expression of the economist's definition, or a corollary to it.

No one will deny the importance of money, but it should always be kept in mind that money is really only a convenient means of exchange and has but little intrinsic value. A roll of thousand dollar bills big enough to choke the proverbial mule would not make a fire big enough to fry an egg on a desert island. So that it is not money which builds our power plants, but human sweat, sore muscles, and knitted brows. The real capital of our industrial world, then, is the stored up labor, mental and physical, of countless ages of men.

Behind the Power Plant

Centuries of scientific and engineering research are behind the design and construction of the machines. The metals are dug from the ground, perhaps years before the building in which they will eventually be used is even dreamed of. The ore is smelted and refined, the metal fabricated. Railroads or steamships, themselves the products of years of capitaliza-

tion, are used to transport the materials to the site of the new plant. More labor and thought to build the plant. When it is all finished, what? Well, it is much easier to push a button on the wall than it is to wait for the moon to come up, but there are a few million years of work behind that button.

If then, capital is accumulated labor, why is capital always thought of in terms of money? Under our present system a man exchanges his labor for money with which he can acquire those goods which are needed in order for him to live. If his labor is valuable, or if he is fortunate, he receives more money than he actually needs for mere existence. He may then go to a ball game, or he may put the dollar in a savings bank. Twenty years later he has either the memory of Casey fanning with the bases full, or he has two dollars. It's up to him. Every one has the privilege of trading in his excess labor for a present want, or of storing it up as *capital* for the future needs of himself and others.

But why should a man who puts his money in the bank be entitled to more than he put in after a period of time? Principally because of the quite human failing of discounting the future. There would be no difficulty in making a choice between having a hundred dollars now, or in having a hundred dollars ten years from now; but most men, if offered the choice between a hundred dollars now and two hundred dollars ten years from now, would at least stop to think.

Opposing Factions

The disputes which so often arise between "Labor" and "Capital," are in truth disputes between Labor and Management. Since capital is really accumulated labor, and in fact is largely owned by wage earners, although it is more or less controlled by a relatively small number of "Capitalists," a quarrel between Labor and Capital reduces to something like shadow boxing. The worker should be the last one in the world to object to capital receiving a fair return since he himself would suffer as much as anyone. The real difficulty quite often lies in the Management of industry.

If a man has sufficient foresight and acumen to employ someone else's money to operate a successful and profitable business, he deserves to be compensated accordingly. Thus, Management has two sources of income. There is a certain amount of highly skilled labor which should receive a just salary, and there is the managerial ability which is paid by the profits of the business. The top men in industry today receive, in general, high "salaries" which are really combinations of wages and profits. They certainly are entitled to wages for what they do determine whether the business is operating at a profit or not, but when there are no profits these men should not share in something which does not exist.

Yet this is exactly what happens all too often. When business is bad and operating at a loss the industry's surplus is called upon to make up the deficit. Wages are cut all along the line, from the president down to the office boy. But these wage cuts are very often uniform, or nearly so, whereas the high salaries which are more than one-half profits should be cut in two. Rarely is this done, and when conditions improve slightly the workers immediately demand an increased share of the income of the business, citing the fact that they were called upon to bear the brunt of the difficulties. The Management replies that the profits of the business do not warrant any wage increases, and that higher wages would have to be reflected in higher prices, which in turn would diminish the volume of business and further reduce profits—the good old time-worn vicious cycle. So the workers strike, and get no wages. The business makes no profit, and pays no dividends or interest on its obligations. The stock goes down in the "market," and the insurance companies reduce their policy dividends and the banks their interest rates. The worker loses both as a wage earner and a Capitalist.

So, the greater part of the industrial unrest in the world is not caused by the Capital-Labor feud, but by differences between the worker and the management. Many plans in which the workers own all the stock in a business, or in which the workers share the profits in some form, have failed to work out because the same old friction with management was still present. In these cases the workers in a plant are more than ever capitalists, but they still have no voice in the management. I believe that a long step will be taken in the solution of labor difficulties when the rank and file of workers realize this fact. The so-called labor leaders have known it for a long time.

Government ownership is not the answer. This merely shifts the ownership from some of the people through savings to all of the people through taxes. The worker becomes a part owner in the business willy-nilly. He cannot choose between a present need or an investment for the future; he cannot even choose the form of his investment. He receives his return on his investment not as interest, but in the form of reduced prices. If he has no particular use for the commodity in question, he receives no return at all and some one else is getting a larger return on his tax investment than is warranted. The old cry that certain projects are so big and so expensive that only the Government can undertake them is only a half truth. If there were a real public demand for these projects, and if *they could be made to pay,* private capital would be available in almost any amount to finance them. But no man is willing to put his savings, be it a hundred dollars or a hundred million, into a scheme that may prove beneficial to his grandchildren's children.

Government ownership will not remove the difficulty of the management problem, either. The whole people will have a part ownership in the business, but they will still have no voice in its management. True, there is the ballot, but it is hard to conceive of a campaign based on the issue of whether the Government should use 900 or 950 deg. steam temperature in its power plants.

With these few concepts in mind, it might be well the next time you hear something to the effect that it would be a good stunt to take all capitalists aboard a boat and sink it in mid-ocean, to think of all that last five dollar deposit in the bank, or the new coal bin in the cellar, and say indignantly, "Who? Me?"

Blast Furnace Gas As a Boiler Fuel

Limited in its use by the method of production, low heat value, its dust content and intermittent supply, blast furnace gas is strictly a by-product fuel so far as power generation is concerned.

By GEORGE L. RADAMAKER

BLAST FURNACE gas has qualities which make it applicable to plants burning other types of fuel, even though its production and use is confined to the steel mill. Fuels with such low heat value (90 B.t.u. per cu. ft.) as blast furnace gas are seldom used in other plants and industries, but it is believed the data and operating procedure obtained from burning this fuel in a modern high-pressure plant may be informative and influence the design and operation of future plants using higher heat value fuels.

The plant around which the following article is written is a modern industrial steam generating station, built in 1937, operating at 460 lb. pressure and 750 deg. F. steam temperature and having a total steam capacity through three boiler units of 1,000,000 lb. per hr. Steam is supplied to a 25,000-kw. turbo-generator, three turbo-blowers supplying air to the blast furnaces and a low pressure steam line of 150 lb. pressure.

Blast furnace gas because of its low heat value (90 B.t.u. per cu. ft.) is not suited to household use. Another disadvantage is that the amount of dirt entrained in the gas and the cost of cleaning for commercial use would make blast furnace gas unable to compete with natural gas or other high heat value gases on the market. The production of iron also determines the quantity of the gas available. Blast furnace gas then becomes a waste gas with possibilities as a fuel but with its production dependent on the iron production of the blast furnaces.

The Blast Furnace

In order to acquaint those unfamiliar with steel mills, and to discuss more accurately the use of blast furnace gas as a fuel, a brief outline should be given of its source, the blast furnace.

Air is supplied to the blast furnace, at present, either by steam turbo-blowers or by reciprocating gas engine blowers at a pressure of about 12 to 20 lb. per sq. in. depending on the required output of iron from the blast furnace, the greater the output the higher the pressure and the greater the flow of air. The blowers supply this air to the hot blast stoves at 100 to 150 deg. F. where the air is heated to 1000 to 1200 deg. F. The hot blast stoves or air heaters as they are sometimes called are of the regenerative type necessitating a change of the air passage to another stove as one cools off.

As the air passes up through the mixture of coke, limestone and iron ore in the blast furnace, the coke ignites forming carbon monoxide which in turn smelts and reduces the iron ore to molten iron which filters down through the mass to the bottom of the furnace. A tapping hole is burned out in the bottom of the furnace and the molten iron is run off into ladles. This procedure is followed every 6 hr. and is known as a "cast". The drop in air pressure through the furnace is considerable. The air enters the furnace at 12 to 20 lb. pressure while the pressure on the main from the blast furnace to the gas engines and boilers has a pressure of only 12 to 30 in. of water.

The air in its passage through the blast furnace forms carbon monoxide and carbon dioxide by its reaction with the coke and iron ore. Carbon dioxide is also formed from the decomposition of the limestone ($CaCO_3$) which in turn is partially reduced to carbon monoxide by reaction with the coke. Of course the nitrogen in the air passes through unchanged, while some hydrogen is picked up from the coke. An analysis of an average sample of blast furnace gas as it comes from the blast furnace is about as follows:

CO_2	14.4%
O_2	
CO	25.0%
H_2	2.7%
CH_4	0.2%
N_2	57.7%
	100.0%

The blast furnace gas after leaving the blast furnace is run through a scrubber or gas washer where it becomes a primary washed gas with dirt entrained in the gas amounting to about 0.2 grains per cu. ft. The temperature drops to about 50 deg. above atmosphere in its passage through the gas washer and reaches a temperature close to that of the atmosphere in passing through the gas main.

Boiler and Furnace

The boiler and furnace of each unit have an overall height of 72 ft. 9 in. from the ash pit to the boiler roof. There are three blast furnace gas burners, two natural gas burners, a natural gas pilot light, and two power oil burners arranged in a vertical line in tiers at each corner of the boiler. Firing is done at the four corners of the furnace, and the burners are set so that the gases do not shoot directly to the center of the furnace but slightly to the right of center so as to produce a swirling motion.

Air is heated by a regenerative type air heater and furnished to the boiler by either a steam turbine forced draft fan or a motor forced draft fan or both, if needed, through a common windbox. Windbox pressure is regulated by seven louvre dampers at each corner and air flow by regulation of the speed of the forced draft fan or the opening of the dampers at the fans.

Furnace pressure or draft is controlled by speed regulation of a steam turbine induced draft fan and damper or by a two speed motor induced draft fan and damper or both if required. Furnace pressure is maintained at —0.2 in. of water.

The boiler is of the four drum water tube type, with economizer, water walls, air heater and superheater.

Operating Experiences

Because of the low heat value of blast furnace gas, exceedingly large amounts of the gas must be handled to take care of the steam loads. At a steam load of 100,000 lb. per hr. it is necessary for the induced draft fans to handle 3,200,000 cu. ft. per hr. of burned gas at about 300 deg. F., or 50,000 cu. ft. per min. Whereas at a steam load of 225,000 lb. per hr. nearly 9,000,000 cu. ft. of hot gas will pass through the fans and out the stack each hour or about 150,000 cu. ft. per min.

Although the boilers are rated at 330,000 lb. of steam per hour, due to the very large amount of combustible used when burning all blast furnace gas, the capacity of the induced draft fans, friction of flow through burners, and gas temperature and pressure in gas main, the load on the boilers is limited to about 250,000 lb. of steam per hour. Dirt entrained in the blast furnace gas cakes around the passage at the mouth of the burner and at sharp changes of direction of the gas entering the burner which reduces the area of the burner thus further reducing the flow of blast furnace gas to the furnace. In order to take care of loads higher than can be handled by all blast furnace gas, natural gas or oil must be used as a secondary fuel to make up the difference because of their smaller volume. All the blast furnace gas possible must be used and oil and natural gas because of their higher cost must be kept at a minimum.

The gas engine blowers and generators take their supply from the same main that supplies the boiler units, but the gas engines require a minimum gas pressure of 12 in. of water, otherwise trouble is experienced in their operation. In case the blast furnace gas pressure begins to drop, the boiler operator cuts in natural gas or oil thus reducing the flow of blast furnace gas and raising the pressure on the main. The blast furnace gas is used in gas engine blowers and generators, the soaking pits for rolling mills, and for the blast furnace stoves, it is therefore necessary for the boiler operator to watch this pressure constantly and keep it above its minimum of 12 in. of water but not waste any by keeping the pressure below 21 in. so as not to bleed any to the atmosphere through the relief valve which is set at 21 in. of water. At the finish of a "cast" the air pressure to the furnace must be dropped in order to plug the tapping hole with mud or clay. Consequently since the air supply pressure is dropped the flow of gas leaving the blast furnace will be reduced, the blast furnace gas main pressure drops and natural gas or oil must be cut in as explained above.

The appearance of the combustion chamber when burning blast furnace gas probably looks strange to those familiar with burning other gases, liquid fuels, or solid fuels. Instead of the bright almost white incandescent light that must be viewed through a colored glass, there is a pale blue color that is so transparent that the inside of the whole furnace may be viewed with the naked eye. Practically the only light inside the furnace is caused by the pilot lights at the corners which burn a total of 5000 cu. ft. of natural gas per hr.

Because of the relatively large volume of the products of combustion and the low heat content, the temperature of combustion is considerably lower than that of other fuels. Also, the flame being non-luminous, or nearly so, radiant heat is considerably less than that found with other fuels. With these two facts in mind the boilers were built with convection type superheaters with no radiant heating surface exposed, steam temperature being controlled with a bypass damper.

In the combustion of blast furnace gas the pressure at the burners varies between 1 and 6 in. of water, air windbox pressure varying between 0 and 2 in. of water depending upon the number of gas valves and air dampers open and upon the steam load. At low loads the blast furnace gas and air have a comparatively low velocity, and when oil is burned as a secondary fuel with blast furnace gas this lazy type combustion results in a smoky combustion chamber at the burner level, but because of the large furnace volume this clears up before reaching the boiler tubes and no carbon monoxide is found in the gases passing out the stack.

Using 15 to 20 per cent excess air, which is necessary to avoid any carbon monoxide in the stack, a flue gas analysis shows about 23.5 per cent CO_2. This abnormal looking figure results from 14.4 per cent CO_2 carried in with the supply. Under each boiler, 5000 cu. ft. per hour of natural gas is burner in the pilot lights, but because of the large volume of the blast furnace gas this natural gas has an effect of only ¼ of 1 per cent CO_2 in the flue gas so is not considered in the analysis.

Accidents

In all power plants, hazards are present and accidents occur, although it may be stated infallibly that all accidents are preventable, their exact cause and

a remedy to prevent their recurrence is often a matter of speculation. An accident occurred at this station at the beginning of a soot blowing period, although not disastrous it did cause some damage to the boiler setting.

At this time, the load on the unit was comparatively light, about 80,000 lb. of steam per hour. Blast furnace gas and air enter the furnace at a fairly low velocity at this load. At this load the low velocity of the combustible does not cause the turbulence and mixing in the furnace experienced at higher loads. It must also be noted there is a distance of about 20 ft. from the ash pit to the bottom of the burners. In this space there is comparative quiet and it is believed that in this space an explosive mixture collected. When the soot blower was turned on in the first pass it agitated this region carrying the gas up into the flame and igniting it. The gas explosion that resulted caused a bulge in the plates at the ash pit and raised the plates on the furnace roof at the seam exposing a gap that measured almost 12 in. in some places. No damage occurred to the boiler drums or tubes, and the operators escaped injury.

At the time the accident occurred all blast furnace gas was being burned. At present the remedy used to prevent a repetition of the accident is to burn natural gas at the rate of 20,000 cu. ft. per hr. during soot blowing periods and to have the louvre air damper open directly below the lowest burner in operation at all times. This, it is felt, will prevent any gas pockets below the burners.

Increased Life for Stoker Parts

AN underfeed automatic household stoker known as the "Templux," is being produced by the Morse Chain Company, Ithaca, N. Y., which is said to be particularly efficient and compact. It is capable of wide variation in its coal burning rate which permits standardization on one size of burner to heat large and small houses. A simple adjustment permits firing as much as fifty pounds of coal per hour, or as little as one pound.

These stokers are claimed to be particularly effective in reducing the smoke nuisance. The air and gases are intimately mixed to assure complete combustion and the temperature of the bed is high enough to ignite the carbon particles which would otherwise pass off as smoke.

In order to operate at these high temperatures it has been found desirable to use an alloy cast iron which is an extra fortified form of Inco Spec. A-1* of the following composition, for the retort tuyeres and other castings exposed to direct heat, to minimize growth and warpage.

Total Carbon	3.30/3.40%
Silicon	1.80/2.00%
Manganese	0.60/0.70%
Chromium	0.40/0.60%
Nickel	1.40/1.60%

In a large measure, the failure of unalloyed grey iron stoker parts is caused by internal oxidation of the matrix by hot furnace gases which work their way into the heart of metal through the large soft graphite particles. In this manner, the sound metal adjoining these flakes is adversely affected in that its carbide structure is decomposed into compounds which occupy more volume than the original structure and hence cause permanent volume changes which result in growth and warpage. The alloys provide increased resistance to this type of attack because they exert a stabilizing influence on the matrix, thereby minimizing carbide decomposition, and form a tightly adhering surface scale which retards penetration, also producing more finely divided graphite less easily broken down by the hot gases.

Pipe Standards

AMERICAN STANDARDS ASSOCIATION recently announced approval of a new standard for Dimensions and Materials of Wrought-Iron and Wrought-Steel Pipe and Tubing* which should result in considerable savings in cost and convenience to manufacturer and user industries. This standard has been tested through a three-year period of trial in actual use and has already demonstrated its practical value.

Until recently commercial requirements for wrought-iron and wrought-steel pipe were fairly well met by the three schedules for pipe known as standard weight, extra strong, and double-extra strong, that came into use in 1886. The newer methods of manufacture have made it possible to reduce wall thicknesses without a loss in strength, but the old schedules made no provision for the thin-walled pipe which was coming into increased demand. There were no intervening standard thicknesses between the three schedules, and none of the old schedules provided for pipe in sizes larger than 12 in. in diameter.

The new standard consists of ten weight and thickness schedules running from the lightest to the heaviest pipe commonly used. Every effort has been made to coordinate the new with what has gone before. Standard weight and extra-strong thicknesses of the old schedules coincide closely with two of the new schedules. Thicknesses common to both systems are set in boldface type in the new standard. Thus old thicknesses can still be ordered while taking advantage of the new, more elastic schedules.

Twenty-seven associations, technical societies, and government departments concerned with the manufacture or use of piping have participated in the development of these new schedules and it is their recommendation of approval that has led to the new American Standard.

*The new standards B36.2-1939 can be obtained at 50 cts. per copy from the American Standards Association or the American Society of Mechanical Engineers both at 29 W. 39 St., New York City.

PEACEFUL industry can benefit in many ways by a study of policies advocated by military authorities, particularly in the matter of getting things done quickly. Colonel H. A. Toulin, Jr., recently stated a rule that is applicable in every industrial plant. It reads: "Make the best available equipment at once and continue to make it until better equipment can be designed and put into production of equal or greater quantity. This is the priceless rule for war-time success."

Capacitors Reduce Burden On Small Plants

Power factor correction on small generating systems relieve equipment of unnecessary load due to wattless current

By C. G. HART
Westinghouse Electric & Mfg. Co.
Waterloo, Iowa

OPERATORS of many small, privately and municipally owned generating plants are awakening to the opportunity for improved operation and economy which is made possible by the use of capacitors for power factor correction. The increased number of motor driven appliances, neon signs, and other comparatively low power factor devices, which have been placed on all distribution systems during the past few years, are showing their effects in increased heating and losses in generating and transmission equipment, but among the smaller generating plants, only the few which have accurate checks on power factor are fully aware of this condition.

A survey was recently made on a municipally owned system which serves a town in Iowa of about 4,000 population, which showed a power factor at the station

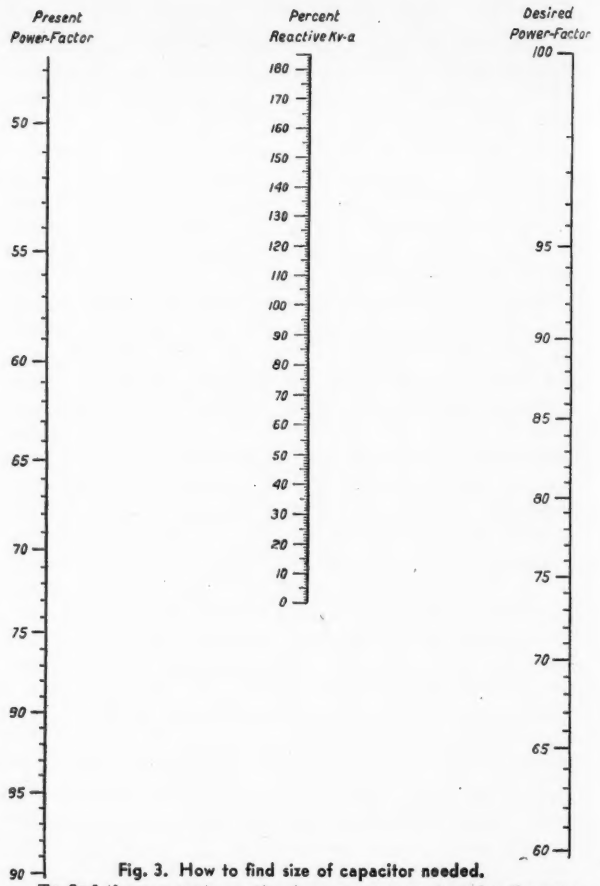
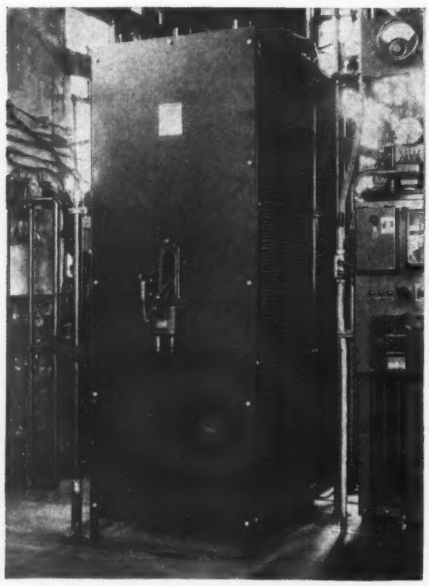


Fig. 3. How to find size of capacitor needed.

To find the per cent reactive kv-a. necessary to raise the present power factor to the desired power factor lay a straight edge across the chart, connecting these two values. Read the per cent reactive kv-a. required on the middle scale. Multiply your present kilowatt load by the per cent reactive kv-a. to determine the size of capacitor to use. 70 per cent present power factor, 402.5 kilowatt load. How large a capacitor is needed to raise the power factor to 100 per cent?

Lay a straight edge across the chart so that 70 on the left-hand scale and 100 on the right-hand scale are connected. The middle scale shows the per cent reactive kv-a. required—in this case 101 per cent. Multiply your kilowatt load (402.5) by the per cent reactive kv-a. (101%) to determine size of capacitor needed. Size of capacitor is $402.5 \times \frac{101}{100} = 406.5$ kv-a.



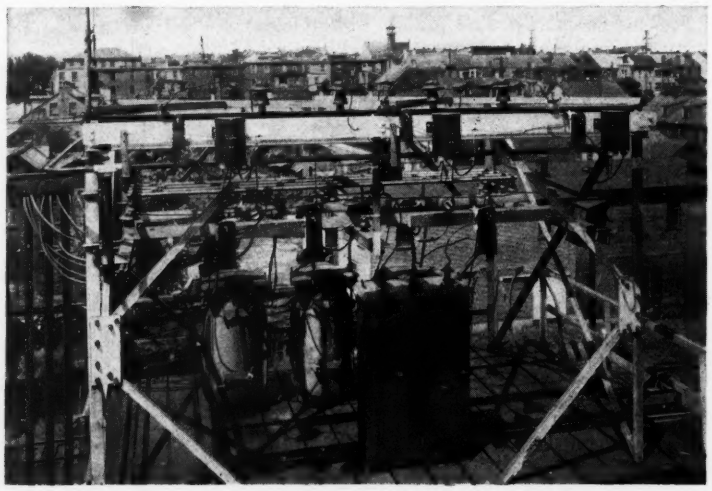


Fig. 1. (Left) 300 kv-a. capacitor installed by the City of Auburn, Indiana.

Fig. 2. (Above) Typical installation of a pole type capacitor.

as low as 70 per cent with an average 400-kw. load. The generating equipment consists of two 500-kw. and one 330-kw. diesel engine driven generators, and the load varies from a minimum of 100 kw. to a maximum which is now slightly over 500 kw. An alert superintendent had found that heating of the generator often required changing from the smallest to one of the larger units as the load increased above 250 kw., long before the kilowatt rating of the generator had been reached. Likewise, with one of the 500 kw. units operating, he found that it was advisable to place another unit on the line as the load approached 450 kw. This was an intolerable condition, especially with plants of this character being matched publicly against each other as to cost of production. The superintendent convinced the city council that power factor correction was warranted and economically sound. 160 kv-a. of reactive capacity raised the power factor from 70 per cent to 85 per cent at the average load of 400 kw. Under peak load conditions, 160 kv-a. of corrective capacity raises the power factor well above 80 per cent. However, this capacity was not installed in one unit, for when the load dropped to 160 kw. or less, a leading power factor resulted. One unit of 100 kv-a. and one unit of 60 kv-a., were installed to best meet all conditions.

A produce plant which is located about three-fourths of a mile from the generating plant has a connected load of 150 hp. in induction motors, and has, of course, quite a large part in the poor power factor condition. The 60 kv-a. pole type capacitor is connected to the primary feeder at this point, thus reducing the line losses in an important feeder and obtaining improved voltage conditions for this section of the town. There are enough small power and residential customers on beyond the produce plant to make this capacitor effective even if the produce plant is shut down.

The 100-kv-a. capacitor is of the indoor type and located in the generating plant so that it can be taken off the line when the load drops below 250 kw. At this point, the power factor will fall slightly below 80 per cent, but the load will still be within the rating of the smallest generator.

It is calculated that when the present load increases and more inductive load is added to the point where additional corrective capacity is desirable, a 60 kv-a. pole type unit can be located out on another feeder, which also serves a small industrial district.

Winnetka's New Generating Plant

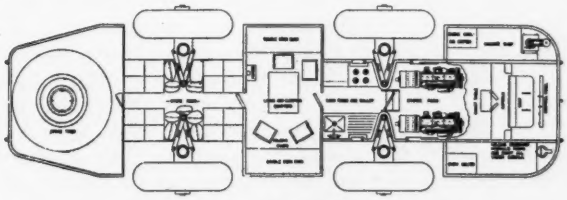
IN THE list of equipment presented in the article describing the new Winnetka Generating Plant of the September issue, several of the items on p. 568 were credited to the sales representative rather than the manufacturer of the equipment. This was not intended. The items credited to J. W. Murphy Co. should have been listed as follows:

H. P. Steam Flow Meters, The Cochrane Corporation.
Draft and Pressure Gages, The Hayes Corporation.
CO_2 Recorders, The Hayes Corporation.
Pressure Reducing and Desuperheating Equipment, Northern Equipment Co., Inc.
Pressure Reducing Valves, Northern Equipment Co., Inc.
H. P. Steam to Existing Plant Desuperheater, Northern Equipment Co., Inc.
Monel Metal Orifices, The Cochrane Corporation. (This item was incorrectly credited to the Bailey Meter Co.)

Diesels for the Snow Cruiser

WHEN the first expedition of the U. S. Antarctic Service under the leadership of Admiral Byrd goes into action in Antarctica they will have a snow cruiser designed and constructed by the Research Foundation of Armour Institute of Technology. Financed by the Institute the cruiser is approximately 56 ft. long and 20 ft. wide will be loaned to the expedition.

It is mounted on four 10 ft. in diam. rubber tired wheels, each driven by a 60 hp. independent motor installed in the hollow wheel spindles. Each wheel has an independent control and the right angle drive incorporates a speed reduction and the power is applied to large ring gears attached to the inner surface of the wheels. Front and rear wheels are independently steered.



Plan of Snow Cruiser

Wheels are equipped with the world's largest pneumatic tires and turn on Timken 24 in. bore by 32 in. length bearings having a load capacity of 91,000 lb. at 25 m.p.h. and 120,000 lb. at 10 m.p.h. The framework is being constructed at the Pullman plant in Chicago by the Lincoln arc welded process in order to reduce the weight to the minimum and increase the cruising range.

Power for the driving motors is provided by two Diesel engine driven generator sets located in front directly behind the pilot's seat. In addition to the engine room, pilot and navigators spaces, and storage space, there is provided a living space for the crew. An aeroplane carried on the top is expected to enable the expedition to explore and photograph a path 600 mi. wide.

SCIENCE has now attained the greatest accuracy the world has ever known with a machine which measures to the 1,000,000th part of an inch. Called the "profilograph", it employs a magnified beam of light to record microscopic variations in size, and is used in the laboratories of the Timken Roller Bearing Co. of Canton, O., to check the precision of its testing gages so as to insure an accuracy of 1/10,000th of an inch in the manufacture of the company's tapered roller bearings. To picture the minuteness of a millionth of an inch, imagine a human hair split into 3000 equal parts. One part would be approximately equivalent to a millionth of an inch.

All the elements of nature carry on a continuous battle with the natural draft chimney, whose length of service depends upon constant attention to the repair of defects.

Maintenance of Natural Draft Chimneys

By
J. G. MINGLE,
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ONE of the most important parts of a steam plant is the chimney, yet it is astonishing to note the general lack of proper care and maintenance of the average structure of this type. The general attitude of most plant men seems to be that, after being built and placed in service, a chimney is an everlasting structure and that henceforth it needs nothing more than an occasional passing glance from without and a semi-occasional cleaning of soot from within. Only on rare occasions, such as when one is struck by lightning and severely damaged, or develops serious cracks, is the average chimney given any attention at all. Plant auxiliaries, such as fans and pumps, costing less than one-fourth as much, are given daily, and even hourly, attention but the chimney with an original investment of from $25 to $50 per foot of height is usually left to itself.

Many adverse and intensely reactive conditions affect the chimney. The average structure of this type is subjected to the injurious effects of the gases from the products of combustion, weathering from the atmosphere, strong winds and oftentimes tornadoes and hurricanes, extremes of weather conditions, intense internal stresses caused by temperature differentials, occasional earthquakes, lightning damage during thunder storms, and others. They are often the victims of such carelessness as the collection of soot which occasionally ignites in the lower part and burns with disastrous results. Improper breeching connections which allow the cool outside air to infilter and lower the chimney-gas temperature are all too common. Cracks due to several causes are allowed to open up with even more disastrous results. It is indeed difficult, in the light of the care given to other parts of the plant, to fathom the general attitude towards the maintenance and care of this very important plant auxiliary.

Steel Stacks

Steel chimneys, or stacks as they are more commonly called, generally are better maintained and kept in better condition than brick and reinforced-concrete structures due no doubt to the fact the results of attacks by these injurious forces are visibly more evident. All steel chimneys should be thoroughly cleaned of rust, dirt and soot on the outside and painted with a thick coat of a preservative paint at least once in 5 yr. Protection and maintenance on the inside can be effected only by the use of a protective lining which will prevent the gases from coming in contact with the metal. An air-space of an inch or less should separate the lining material from the inside of the steel shell. This air-space should be effectually sealed off, so that gases cannot percolate into it through the lining or through the ring-seams of the stack itself. An excellent practice is to fill the air-space with a good grade of insulating material which will not only prevent the escape of heat by convection but also prevent a draft "effect" within the air-space, thereby eliminating further infiltration in case of vents in the lining joints.

The ring-seams of steel chimneys should be arranged so that when the sections are erected in the field the joint will not be directly exposed to the weather. In other words, the bottom of each section should overlap the top of the section directly below. With this arrangement, water and acids cannot collect on the ledges which would otherwise be present and attack the metal. The ring on steel stacks to which the guys are attached should receive particular attention since it is at this region that the most trouble is encountered. The ring should have a beveled surface on top so that water and acids cannot collect and seep into the joint between the ring and the metal of the shell.

The anchor-bolts of self-supporting steel chimneys should be drawn up by means of a long-handled wrench to insure tightness and prevent seepage of water and acids underneath the ring-base.

Too much attention cannot be paid to the maintenance of steel stacks. Their life is short at the best and money spent on maintenance of chimneys of this type is well expended.

Brick Chimneys

Due to their inherent characteristics, brick chimneys, particularly those of the radial brick type, are peculiarly subject to the ravages of the elements and also usage. Despite the fact that they are built of ma-

terials which can withstand severe conditions and their method of construction is sound, they need constant attention and no expense should be spared in keeping them in first class condition.

The chief troubles which are encountered by brick chimneys are the development of vertical cracks and the disintegration of the external mortar joints, particularly those at and near the top of the structure. The chief cause of vertical cracks in the brickwork is due to the fact that the chimney is placed in service too soon after its completion and before the mortar has had sufficient time to attain its proper set. The bond between the mortar and the bricks being destroyed, fine hair-line cracks will appear where the stresses due to temperature differential are localized. In most cases, these cracks are not visible to the eye since they follow along the joints between the bricks and, as a general rule, do not continue through the bricks. After the bond has been destroyed and these surface cracks appear, they gradually widen due to the constant contraction and expansion in the brickwork until they become a source of much trouble and inconvenience. As the surface cracks widen, they gradually open up into the interior of the walls and finally appear on the inside of the chimney. The cool outside air is then sucked through the cracks, mixed with the hot chimney gases and the chimney-gas temperature is lowered as a result. As a consequence, both the draft and the capactiy of the chimney is diminished in proportion to the amount of air admitted.

This tendency towards the development of cracks early in the life of the chimney can be prevented almost entirely by keeping the structure out of service until the mortar has had sufficient time properly to set and form a good bond between itself and the bricks. No brick chimney should be subjected to hot gases for a period of 45 days after it has been completed and a waiting time of 90 days will pay large dividends in later years.

Vertical cracks appearing in brick chimneys which have been in use for several years are generally due to improper construction.

Generally speaking, in ordinary brick chimneys, steel bands made up of strap steel about ¼ by 3 in. in size, usually fabricated in three sections bolted together, are imbedded within the walls directly below each offset in the walls, directly above and below the top level of the lining, directly above and below the breeching opening and two or three are usually imbedded in the corbelled brickwork of the head of the chimney. It would add greatly to the strength and safety of the chimney if, in addition to the above, steel bands were imbedded in the brickwork at 5-ft. intervals throughout the entire height of the chimney. The cost of a band is insignificant and the amount of labor required to place it in the walls of the brickwork is inconsequential. Internal bands imbedded within the brickwork are infinitely more effective in resisting stresses than the unsightly and ineffectual exterior bands which are so often placed on chimneys after the structures have been allowed to crack and when they are being repaired.

While the liberal use of steel bands in the walls of brick chimneys will not always prevent cracks from starting, they will localize them and prevent them from widening and extending in a vertical direction.

While all of the mortar joints of brick chimneys are in time affected by the weathering influence of the atmosphere, those in the upper approximately one-third of the structure are, in addition, peculiarly susceptible to the ravages of the acid gases. When coal is burned, the sulphur content unites with the oxygen of the air to form, among other compounds, sulphur dioxide, which escapes with the chimney gases. When moisture is encountered on the outside of an operating chimney, the sulphur dioxide, being a stable gas and very soluble in water, unites with the moisture (water) to form sulphurous acid. When the minute calcium carbonate crystals, which are formed in the hardening of the mortar, are vigorously attacked by the sulphurous acid, they break down and the mortar then disintegrates as a result. In time, as this process continues, the mortar becomes soft, mushy and lifeless, finally crumbling and falling away. After the crumbling process has continued for some time, the exterior surface of the joint falls away, exposing the inner portions which in turn are attacked by the sulphurous acid. As the dissociation penetrates deeper into the joint, the inner portions also become soft and mushy. The dissociation is greatly accelerated due to the fact that the external surfaces of the joints, being honeycombed, act as a collector of the acid, thereby increasing the intensity of attack and prolonging it as well. Thus the process of a breakdown of a joint becomes a vicious circle.

In repairing chimneys with disintegrated mortar joints, the joints are raked out to a depth of at least 1 in. with a raking tool, the exposed brick surfaces well cleaned and the open joint then pointed with a rich mortar composed of sand, lime and cement. After the pointing has been completed, the joint then should be tooled with a rubbing tool in order to compress the mortar into the joint and also to make its surface more smooth and dense, thereby preventing the sulphurous acid from collecting and remaining on it.

Vertical cracks in chimney walls caused by temperature stresses are usually quite small in width and, in their early stages, are difficult to repair. They are usually termed "hair-line cracks and ordinarily are not of a serious nature. They are an indication that there is distress in the chimney walls and that more serious developments are to occur. As these cracks open up, however, due to alternate contraction and expansion of the brickwork and also to freezing moisture and water which has percolated into the crack, they become serious and special attention should be given to their repair. These cracks usually extend along the shaft in a more or less zig-zag fashion and in a general vertical direction.

Generally the separation takes place between one face of the brick and its adjoining mortar, the crack extending either directly through the center of the bricks below and above the joint or following along the mortar joint in a definite zig-zag fashion. They are repaired by raking out the joint with a raking tool if the joints are soft, or by cutting out the entire joint with a hammer and chisel in case the mortar of the joints is hard and firm, to a depth of approximately 1 in., cleaning the surfaces of all debris and then pointing with a rich mix of mortar. The new pointing should then be tooled with a rubbing tool.

Brick chimneys which have been struck by lightning are oftentimes severely damaged and a difficult problem is involved in repairing them. As a general rule, the damage done by lightning is very erratic. In some cases, the walls of the chimney are rented and torn open from top to bottom while in others the damage is localized to one, or several, regions throughout the height of the structure. The damaged brickwork is repaired in the same manner as a typical crack: all damaged bricks being removed and replaced with new material laid up in mortar and properly pointed. The repair of chimneys damaged by lightning bolts is very expensive and, especially in the more severe cases, the best of repair work still leaves the chimney in a more or less weakened condition. A well constructed lightning rod system, properly grounded, provides insurance against lightning damage at a cost of but a fraction of the cost of the repair work. By their very nature, tall chimneys attract lightning bolts and it is the rankest folly to construct them without protection against this force of nature.

Reinforced-concrete Chimneys

Due to their inherent characteristics, reinforced-concrete chimneys require less maintenance than the steel and brick types. When properly constructed with properly mixed and proportioned concrete and properly located steel reinforcement, reinforced-concrete chimneys seldom require attention for many years after they have been placed in service. If, however, the concrete of which they are built has not been properly proportioned, or mixed, or sufficiently tamped in place in the forms by which they are constructed, the walls may show an early tendency to disintegrate. Likewise, when concrete is placed in the forms during construction in a semi-frozen condition, the walls in the particular section involved will quickly show signs of disintegration. Extreme care should always be exercised in the mixing and placing of concrete during construction in order to insure an everlasting structure.

The great majority of the troubles encountered in the maintenance of reinforced-concrete chimneys can be traced to the improper placing or location of the steel reinforcement. Both the vertical and circumferential reinforcing systems should be located not less than 2 in. from the exterior surface of the concrete walls, or, in other words, at least 2 in. of concrete should surround both systems. When the reinforcement is located near the surface, or is exposed at the surface of the walls, it soon is readily and vigorously attacked by the sulphurous acid resulting from the products of combustion. When once attacked, the progress of deterioration is speedy and the action is progressive as adjacent sections become involved. When reinforcing mesh is used, the smaller interlacing wires are attacked first and, as the oxydation continues, the action spreads to the larger wires.

As the reinforcement oxydizes, it swells and gradually cracks and spawls off the exterior concrete, thereby exposing adjacent sections of reinforcement which soon is attacked in like fashion. Thus the deterioration of both reinforcement and concrete becomes progressively a vicious circle. Hence, the importance of keeping the steel reinforcement well covered with concrete and at a safe distance from the exterior chimney walls can be readily seen.

Unless the region around the breeching opening is well reinforced with steel rods, the walls may develop cracks extending away from the corners and in a direction parallel to the diagonals. At least three steel hoops should be placed above and below the opening. The vertical reinforcement extending towards the opening should be bent around the corners and extended to the sides of the opening. Short rods, or "haunch bars", in addition to the usual reinforcement should be placed at the corners of the opening and at right angles to the diagonals. It is always sound construction to face the reveals of the opening with at least a 2½-in. thickness of a refractory material in order to insulate them from the effects of the high temperature of the chimney gases.

Some reinforced-concrete chimneys develop vertical cracks in the region of the shaft at the level of the top of the lining. This tendency is due to the great temperature differential between the chimney gases in contact with the interior walls and the cooler air in the air space separating the lining from the chimney shaft. These cracks may be localized and prevented from opening up by placing an extra section of reinforcing mesh, or four or five steel hoops of small size rods, in the concrete at this region. This extra reinforcement should also be located at least 2 in. from the interior surface of the chimney walls.

Due to a long persistent and erroneous theory that reinforced-concrete chimneys act as their own lightning protection, many of the troubles encountered in the apparent disintegration of the walls of this type of structure may be traced directly to the insidious effects of lightning damage. When a bolt of lightning strikes the top of a chimney of this type, it is immediately attracted by a vertical reinforcing rod through which it attempts to ground itself. As the bolt attempts to pass through the lap of two vertical steel rods, which are usually very poorly connected, an arcing action takes place and the lightning charge in dissipating itself separates the concrete from the metal reinforcement by a sort of explosive action. If the lightning charge is of high potential, the concrete may be ruptured around the region of the lap to the extent that it will slightly bulge outwards, or it may be blasted away entirely. In either case, the reinforcement becomes exposed to the action of the sulphurous acid, and oxydation due to the elements in the atmosphere, with the same results as described heretofore. In most cases the incipient damage done is not apparent to the eye and the progressive action of the destructive agents is insidious. It is sound engineering practice and a low-priced form of insurance to equip reinforced-concrete chimneys with well constructed lightning rod systems such as are almost universally used on brick chimneys.

Chimneys of all types should be thoroughly inspected at least once in 3 yr. by men experienced in this kind of work and evidences of deterioration should be attended to and thoroughly repaired immediately. Any attempt at a half-way job is money thrown away as the day of eventual repair work thoroughly done is only postponed.

Combustion Control Specifcations

Part IV. Limiting factors of boiler control, load division between units, measurements, instruments and panels

By
RICHARD H. MORRIS
Engineering Editor

ALL PRESENT CONTROLLERS and regulators are in themselves sensitive and fast. Practically, however, there are certain inherent boiler and furnace characteristics, principally heat storage in the furnace walls and boiler water, and, the time lag in heat transfer and steam formation, which limit the effective rate of response. Naturally these effects are less with large water cooled furnace areas and small boiler water volumes, so modern steam generating units are much more sensitive than their predecessors. Nevertheless, a modern boiler may require several minutes to reach equilibrium conditions after a considerable change in load.

Furthermore sudden large increases in air supply are bad with all types of firing. With heavy stoker fuel beds, it may cause nothing more than temporary smoke. With light fuel beds it is apt to cause holes, with loss of capacity and efficiency for a considerable period until normal fuel bed can be built up. With oil, gas and pulverized coal from the bin system it may cause loss of ignition and this danger is materially increased with pulverized coal fired by the direct system.

Each individual auxiliary has its own time lag which must also be considered. Dampers act very fast, but variable speed drives, either steam or electric, are slower due to inertia or to the characteristics of the speed changing device.

Again, flexibility or practical load range of a boiler installation is not a function of the combustion control, but a matter of design necessitated by the load conditions and number of boilers. Increased boiler flexibility costs money, but it is becoming of increased importance as the trend continues toward larger and fewer boilers. With a large number of boilers an operating range of from 175 to 250 per cent may be more than adequate because some of the boilers may be banked at light load periods to keep the load on the operating units within the necessary limits.

As the number of boilers is reduced, the need for a more extended operating range becomes necessary and reaches its maximum in the case, as often happens, when one large boiler is installed with the expectation of a second unit later, or, where two units are installed to divide the load, but with each large enough to carry the entire load in an emergency.

If excessively high peak loads are expected occasionally, the normal operating range should not be forgotten when equipment is selected.

Excepting efficiency from consideration, fans or fuel firing capacity most commonly limit the maximum steam output of the boiler. Determination of the correct size of either is difficult, especially in coal fired plants. Here the coal used and operating conditions such as cleanliness of the air gas passages and, with stokers, the thickness of the fuel bed, have a direct bearing on fan capacity or pressure requirements, but cannot be accurately predicted. Properly balanced, either fan capacity or firing capacity may be the limiting factor under different conditions of operation. In a recent survey of a number of well engineered boilers maximum output was found to be limited by the following:

Table I. Classification by firing methods commonly used

Numbers in parentheses refer to sections and paragraphs of the specifications, Part VI, giving typical data needed in specifications for fuel feed control. Alternate 1 will be found in the complete specifications of Part VI, Alternates 2, 3, 4, etc., will be found grouped in the section immediately following the complete specifications.

A. GAS (Section 3C, Alt. 2)
   1. Gas fired alone.
      (Section 4G, Alt. 2)
   2. Combination of gas and other fuels.
      (Special—not covered by these specifications but should include data as for each fuel alone plus expected method of operation)

B. OIL (Section 3C, Alt. 3)
   1. Mechanical atomization
      (Section 4G, Alts. 3 or 4)
   2. Steam atomization
      (Section 4G, Alt. 5)
   3. Air atomization
      (Not covered by these specifications but similar to steam atomization)

C. PULVERIZED FUEL (Section 3C, Alt. 1)
   1. Unit or direct fired system
      (Section 4G, Alt. 1)
   2. Central or bin system
      (Section 4G, Alt. 11)

D. STOKERS (Section 3C, Alt. 1)
   1. Sprinkling or spreader type
      (Section 4G, Alt. 6)
   2. Overfeed
      (Not covered by these specifications)
   3. Chain grate
      (Section 4G, Alt. 7)
   4. Underfeed
      (Section 4G, Alt. 8)

E. WOOD AND OTHER REFUSE FUELS
   (Not covered by these specifications)

Table II. Classification of the more common drives, transmissions and auxiliaries usually closely associated with automatic combustion control as used in modern power plant practice

Dampers, fan inlet vanes and valves used for control purposes are considered as auxiliaries. The specifications should include full details for those items marked with an asterisk.

Details of the items not so marked are not of special interest to the control manufacturers but the general arrangement should be included in the specifications to assist in visualizing the plant and to avoid misunderstandings.

Information required for a particular piece of equipment is the same regardless of the service, and data typical of those which should be included in the specifications can be located by the references given in parentheses. In these references, Alternate 1 is in the complete specifications in a later section, Alternates 2, 3, etc., are grouped together following the complete specifications and can be readily located from the index.

DRIVES

A. STEAM DRIVES. One of the principal advantages of steam drive is speed flexibility but it is sometimes used at constant speeds for heat balance purposes or by-product power generation.

1. Constant speed turbines or engines.
   (See constant speed a.c. motors)
2. Variable speed turbines* or engines* with speed control*
   (Section 4G, Alt. 10)
   (Sections 4H and 4I, Alt. 2)

B. MOTOR DRIVES

1. Direct Current. This offers good speed flexibility but d.c. is seldom available in the plant and is usually used only for small motors where low efficiency, due largely to losses in motor generator sets, is not important.
   a. Constant speed motors
      (See constant speed a.c. motors)
   b. Variable speed motors* with multipoint resistor*
      (Section 4Gc, Alt. 1)
   c. Ward-Leonard
      (Special—not covered by these specifications)
2. Alternating Current
   a. Constant speed motors. Induction motors with across the line starters are most common.
      1. Direct, belted, or geared drive motor and starter
         (Section 4Ga, Alt. 1)
   b. Multi-speed motors or drives.
      1. Pole changing induction motor* drive and starter*
         (Section 4Hb, Alt. 1)
      2. Two constant speed motors* and starters* each
         (Similar to section 4Ga, Alt. 1—give data for each motor as well as details of starters)
      3. Four speeds—two single speed motors* and differential gear*
         (Special—not covered by these specifications)
      4. Multi-speed slip ring or wound rotor motor* with multipoint resistor*
         (Not covered specifically but see Section 4Gc, Alt. 1)

C. SPECIAL VARIABLE SPEED DRIVES

   a. Brush shifting motor*
      (Section 4Gb, Alt. 8)
   b. Rossman drive*
      (Special—not covered by these specifications)
   c. Electron tube control*
      (Special—not covered by these specifications)

*Indicates that full and complete details of equipment so marked should be included in the specifications. Details of items not so marked are not essential.

TRANSMISSIONS

A. CONSTANT SPEED

1. Flexible couplings
   (Section 4Hb, Alt. 1)
2. Belts—flat or Vee (See A1)
3. Gears (See A1)
   (Section 4Ib, Alt. 1)

B. VARIABLE SPEED

1. Mechanical Speed Changer*
   (Section 4Gb, Alt. 7)
2. Hydraulic transmission*
   (Section 4Gb, Alt. 9)
3. Hydraulic couplings*
   (Section 4Ib, Alt. 1)

NOTES FOR ALL COLUMNS

When an auxiliary is driven by a constant speed prime mover, details of the prime mover itself are of no particular interest to the control manufacturer (beyond assurance that it will pull the maximum load at rated speed and have adequate speed regulation) for the control must operate through secondary devices such as dampers, valves, or variable speed transmissions, etc. Full data on these secondary devices and method of operation should be included in the specifications.

With variable speed prime movers, motors, turbines or engines, full details of the prime mover itself and method of speed control are of vital interest to the manufacturer and should be included in the specifications. If, as is sometimes done with fans, a combination of damper and variable speed drive is used, full details of the speed control, the secondary device and the method of operation should be included. If the rheostat, speed control valve or governor is to be furnished as part of the combustion control, state this specifically and include current characteristics of pilot motor circuits.

Transmission is of special interest to the control manufacturers only when it is used as a variable speed device between a constant speed drive and a variable speed auxiliary. In this case it is the point where control must be applied and full details must be given. For any variable speed device, include the make, type, size, speed range, operating force required, method of applying control force fixed lever arms, plane and arc of travel, etc.

Notes on specific auxiliaries are included at the right but no reference is made to tachometers. With some types of control, the stoker or pulverizer feeder speed is used as a metered indication. While this cannot be used in all cases, and is never used by some controls, it is well to include in the specifications the location, speed range and other details of a shaft from which a blower or electrical type tachometer can be driven. On pulverizers where the air flow through, or pressure drop across, the mill is employed as an indication of the coal delivery to the burners, the pressure difference at three loads through the operating range should be included.

AUXILIARIES

A. DAMPERS* AND INLET VANES*

Drive determined by make of control purchased. For standard purchased equipment include flow, pressures and temperatures at or across the damper together with the make, size and type with sufficient data to identify in manufacturer's catalog. For special construction add dimensions, design details, mechanical linkage and fixed lever arms lengths, are of travel, operating torque and characteristics insofar as possible. Emergency or shut off dampers operated by hand should be mentioned but details not necessary.

(Dampers, Sections 4Hc, Alt. 1 and 4Ic, Alt. 1)
(Inlet vanes, Sections 4Hb and 4Ib, Alt. 3)

B. CONTROL VALVES* AND SPEED GOVERNORS*

Include data as for dampers. If used as speed governor for a steam drive identify the drive and give data on make, type, size, etc. If the valve is to be applied as part of the control make specific mention of it and include data on flow, pressure, temperatures, pipe size and type of flange desired. If valve is purchased separate add valve lift and pressure drop across valve at rated capacity.

Valves (Gas, Section 4Gc, Alt. 2); (Oil, Section 4Gc, Alt. 3, 4 and 5); (Steam, air and water control valves not covered specifically but data should be similar to above)
Governors (Section 4Hb and 4Ib, Alt. 2)

C. FORCED AND INDUCED DRAFT FANS.*

Include make, type, size, capacity, static pressure and characteristics of fans (Sections 4Ha, Alt. 1) together with other data as outlined below for different drives.

1. Constant Speed. Motor drive with damper or vane control.
   (See damper and inlet vanes above, also Section 4Hc, Alt. 1 and Section 4H and 4I, Alt 3.)
2. Multi-Speed* May or may not include auxiliary damper or vane control between stages. If so, both the dampers and speed steps may be controlled automatically or the speed steps may be controlled manually. In addition to data on equipment. details of operating procedure must be included. (See Section B under Drives, also Sections 4H, Alt. 1 and 5Cf, Alt. 1)
3. Variable Speed*. Due to inertia effects with large fans and some drives or inherent time lags in speed changers, auxiliary damper operation may be advisable. (See multi-speed above, Section B under Drives, and Section B under Transmissions.)

(Continued on next page)

Table II. Data on Auxiliaries continued from third column of previous page. General notes will be found near the center of the previous page

D. STOKERS*. Requires flexible speed control with good regulation under varying loads. Slip ring a.c. motors and series wound d.c. motors not desirable because of characteristics and two speed motors and gear boxes not well suited to automatic control. Include data on stoker make, type, size and fuel burning capacity. State if multi-speed gear box included in drive and if so give speeds, effect on output and whether it is to be used in normal control range. Also mention whether control manufacturer or is to supply speed control valve or rheostat and give necessary data. (Section 4G, Alt. 6, 7 and 8)

1. Constant speed. Used on spreader stokers. Give full details of ratchet or control arrangement on stoker feeder.* Section 4G, Alt. 6)
2. Multi-speed* A.c. or d.c. motors with multi-point controllers. See type of drive for data needed. Section 4G, Alt. 8)
3. Variable Speed*. May be through hydraulic drive, mechanical speed changer, steam engine or turbine, brush shifting a.c. motor or shunt wound d.c. motor. See type of transmission or drive for data needed. (Sections 4G, Alt. 9 and 10)

E. PULVERIZERS AND PRIMARY AIR FANS.

Usually driven at constant speed by either turbines or motors. Drives of no particular interest to control manufacturer but include number, make, type and size of pulverizers, arrangement of mills, feeders and fuel control. (Section 4Ga and d, Alt. 1)

F. PULVERIZER FEEDERS* (Complete data needed only when directly under combustion control)

Raw coal feed may or may not be directly under the combustion control, depending upon the make of mill and feeder. Specifications should be definite about the actual or contemplated arrangement, make, type, size and drive of feeder and whether the combustion control is to regulate the raw coal feed (Section 4Gc, Alt. 1) or the air-coal mixture (Section 4Gc, Alt. 12) to the furnace. State whether a multi-speed gear box is included and if it is give speeds, effect on output and whether it is to be used in normal control range.

1. Constant speed.
   a. Belt or gear drive at constant speed. Raw coal feed regulated by combustion control through position of knife or plow on rotating table. Often provided with gear box, manually operated, to give two table speeds. Make, type, number, size of feeders, gear box details, force and range of travel of element to be operated is usually sufficient for specifications. (Section 4Gc, Alt. 14)
   b. Intermittent feeder operation* May be "on and off" type, variable stroke or ratchet arrangement under independent automatic control or under combustion control* Give make, type, and size of feeder, data on ratchet drive and force and range of element to be operated. If feeder is not under combustion control tell how fuel to furnace is controlled. (Section 4Gc, Alt. 12 and 13)
   c Mechanical speed changer (See speed changers above)
2. Variable speed* Shunt wound d.c. or brush shifting a.c. have desirable characteristics for this service. Give data on motor and controller. See (Section 4Gc, Alt. 11) for central or bin system of pulverized fuel firing. (Section 4Gc, Alt. 1)

G. BURNERS
Pulv. Coal (Section 4Gb, Alt. 1)
Gas (Section 4Gb, Alt. 2)
Oil (Section 4Gb, Alt. 3)

H. FUEL OIL PUMPS
1. Constant speed a.c. motors (Section 4Ga, Alt. 4)
2. Variable speed steam pumps. Usually controlled by independent regulator set to hold constant oil pressure. (Section 4Ga, Alt. 3)

Fans, 10; fuel bed or combustion, 6; slagging, 2; piping pressure drop, 2; excessive superheat, 1.

Minimum operating limits are most commonly set by fuel firing conditions either by the minimum possible speed of firing equipment or unstable combustion conditions. In the same survey minimum operation limits were set by fuel firing or combustion conditions in fourteen cases and in the balance by the following miscellaneous causes: Boiler circulation; draft control; excessive superheat; air heater sweating; slag tapping. With stokers the minimum range can be extended by lowering the minimum speed limits; with pulverizers by installing two or more units and with pulverized fuel, oil and gas by installing several burners so that the number in operation can be reduced at low loads. Excessive superheat as a limiting factor in both minimum and maximum ratings is accounted for by the different characteristics of radiant and convection types. With radiant superheaters, steam temperature is highest at low load, while with convection superheaters steam temperature is highest at heavy loads. Combining the two in series has proved to be a simple and practical method of controlling superheat.

Unfortunuately, an exact balance between all auxiliaries cannot be made and the final design is a matter of experience, judgment and economics. In an effort to set a rational basis of design a N. E. L. A. committee several years ago reached some interesting conclusions. Based on 100,000 lb. per hour steam flow, steam pressure loss was evaluated as $136 per year per pound of loss and superheat at $400 per year per deg. F. temperature change for a 1200 lb., 750 deg. F. top plant. More complete figures for a 400 lb., 750 deg. F. condensing plant on a yearly basis were: $3 per lb. of water pressure loss; $50 per lb. of steam pressure loss; $140 per deg. F. superheat change; $65 per deg. F. exit gas temperature change; $310 per in. of induced draft loss; $2300 for each per cent change in efficiency. Obviously these figures are applicable only for certain specific conditions, but they do serve as a relative measure of the importance of the several factors involved.

Another point that must be considered by both the designer and operator is the division of the total load between different boilers. There is considerable difference of opinion on this point among engineers and only the most general conclusions can be drawn. With all boilers of the same type, size and characteristics, load is generally divided evenly between the units in operation. Sometimes, however, certain boilers are operated at their best efficiency point at constant load and the swings taken by one or two units. This is apt to be the case in plants having boilers of different sizes and types installed at different times. The ability to limit the output of a given boiler or to operate it at constant load to meet temporary operating conditions often is desirable.

Practically all control systems incorporate means for automatic, semi-automatic, and, remote operation, but it is well for the designer to review carefully the expected method of operation and specify carefully what is wanted. Automatic control normally divides the load evenly or proportionately between boilers, semi-automatic control makes it possible to put any or all boilers on constant output at any desired rating,

while remote control or positioning allows manual operation and is provided primarily for cutting a boiler in or out of operation as easy as possible.

The usual procedure is to bring the boiler up to minimum rating manually and then change over to automatic control. Changing the number of burners or pulverizers in service is also best done manually. Combustion control should be kept as simple as circumstances permit, even though it is entirely practical and possible to extend it much farther. It should be remembered that extension to include functions which might just as well be done manually serves no useful purpose and adds to the complexity. Control equipment like every mechanism requires care and attention if it is to operate properly, and, the more complex the greater the care and maintenance necessary to maintain a given standard of performance.

Automatic control is based on certain measurements and performance depends upon the accuracy with which these measurements can be, or are, made. Combustion control depends primarily on steam pressure, air flow, fuel flow and furnace draft measurements, but other measurements such as steam flow, CO_2 and various pressures and temperatures may be utilized as secondary control points, or for the guidance of the operator in making adjustments on the automatic control equipment itself, or, at points which have been left for manual operation.

As far as the control system is concerned, provision should be made on the steam header for a pressure connection to the master controller and for an orifice for steam flow measurement. The latter is used directly by the combustion control of but one company, but provision for steam load measurement should be a part of every well operated plant. The orifice location is the more critical and should be preceded and followed by a considerable run of straight pipe if the readings are to be relied upon. The pressure connection is less critical, but should be placed so that it is not affected by pressure variations and eddies caused by bends and elbows.

Furnace connections should be made with some care, particularly in very high furnaces where the chimney effect due to the difference in density between the air outside and the gases inside of the furnace may be considerable. The pressure change per foot of elevation is less inside than outside the furnace, and if the control point is too low a slight negative pressure there may give a positive pressure at the top of the furnace. At no point in the boiler or furnace should the pressure be positive, or higher than atmospheric, for that results in loss of air or gas through furnace openings, increases refractory maintenance and aggravates blow-backs which endanger the operators. Too high a draft or suction in the furnace increases air infiltration through cracks, lowers efficiency and throws an undue load on the induced draft fan.

Probably the most difficult measurement is that of air flow used for the purpose of holding the proper air-fuel ratio. Occasionally the air flow may be measured by an orifice or venturi in the air duct or from the pressure drop across the air heater if one is used. The difficulty here is that the primary air through the pulverizers and overfire air for stokers cannot always be included so that only a portion of the total air used for combustion is measured. Again the proximity to dampers, bends and guide vanes may make the flow indications erratic.

The more common way is to get relative air flow indications by measuring the draft loss across a certain section on the gas side of the boiler. The relation between air and gas flow for given conditions is, for practical purposes constant, and this method is entirely adequate in most cases. With some of the newer low draft boilers there may be difficulty, however, because there is not a sufficient draft loss to give a reasonable indication of the flow. Again from an operating standpoint draft loss indications of flow are subject to change with the cleanliness of the gas passages, changes in baffling and, in the newer boilers using bypass control of steam temperature, the position of the damper. The location of the taps should, therefore, be across the section least subject to slagging, baffle troubles or disturbances caused by baffles.

An indication of fuel flow, if needed for control of the fuel-air ratio, it is usually provided by the control manufacturer and is selected to meet the needs of the plant layout and control equipment used. In many cases adequate measurements of fuel flow for combustion control purposes can be made with tachometers measuring stoker or pulverizer feeder speeds. If high boiler efficiency and automatic control are a factor, and it always is, a prospective boiler design and auxiliaries should be viewed quite critically by the plant designer to insure that proper measurements are both possible and practical.

Other measurements made available for the guidance of the operator vary with personal preferences and with the auxiliaries selected. They usually include: the boiler drum pressure, header pressure, water level, steam flow and temperature, feedwater temperature, pressure and flow; temperature in and out of the air heater; draft indications at the uptake, furnace, windbox, in and out of the air heater and load or speed indications necessary and advisable for specific auxiliaries. Usually a combination of indicating and recording instruments is used.

These instruments are usually grouped together on one or more panels. In small plants the automatic regulators are often located at the damper or machine to be controlled with only the instruments on the panel. In larger plants, especially where remote control is necessary or advisable, a large part of the control system itself, is commonly centralized on a panel or panels. If this is done the instrument panels and control panels are often combined. The shape, size, arrangement and even the location of the combined panels are greatly influenced by the make of control system so that a detailed layout cannot be made until the control is purchased.

It cannot be emphasized too strongly that a boiler or boiler plant should not be considered solely from the standpoint of separate auxiliaries but from the standpoint of how these auxiliaries operate together as a coordinated unit. Within the load range desired this coordination is largely a matter of control. A plant which is easily operated manually is easily operated automatically and at higher average efficiency.

(To be continued)

The PRACTICAL ENGINEER

DEVOTED TO PLANT OPERATION and MAINTENANCE

A. W. KRAMER, EDITOR

HELP, HELP!

In expressing his interest in the "Practical Engineer" one of our readers indicates a desire to see more data and information on equipment costs and suggests that an entire department be devoted to this subject. We think this a swell idea and would be tickled pink to run such a department; indeed, we would do so in the next issue were it not for one detail—we haven't the information. Equipment costs, in fact cost data of any kind, are extremely difficult to get; consulting engineers are usually not at liberty to release cost data and it is worse than pulling teeth to extract cost data from manufacturers. As a consequence there has been a dearth of information on this subject in the technical magazines.

In commenting on this state of affairs we do so with a purpose. You operators who read these pages, at various times have bought power plant equipment and know how much it costs. It may have been an entire new plant or merely a new stoker or forced draft fan but whatever it was you have the cost data and this information is of value to others. We would like to have you send information of this kind to us. If you do, we shall be glad to compile it from time to time and publish it in a form which will enable everybody to benefit from it. This data, naturally would be presented without disclosing your identity should you have reasons for having it withheld.

So if you have equipment cost data in your files, please send it on to us. We will see that it is put to good use.

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A Section of Power Plant Engineering

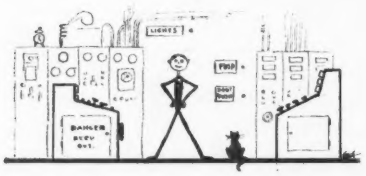
TECHNICAL PUBLISHING COMPANY

53 WEST JACKSON BLVD., CHICAGO, ILL.

Judging by visits to some of the new power plants, overalls, the old oil can and other appurtenances once commonplace in the power plant, have been relegated to the scrap heap. In their place we find white collar engineers, push buttons and pH values. So the obvious question is, "where is the old time practical engineer?" The answer is simple, he is still there but often wears the white collar.

Clothes Do Not Make An Engineer

SEVERAL weeks ago I stood in the main control room of the new Ottawa Street Station in Lansing.[1] In front of me was a beautifully designed benchboard, smooth and sleek in outline, fashioned of steel and equipped with an amazing array of control knobs, indicating lamps and measuring instruments. On its face it carried a diagrammatic layout of the high pressure steam and water lines for this was the boiler control board. Immediately behind me was another benchboard, similarly equipped with switches and control gadgets; this was the main electrical control board. At the sides of the room were other panels—vertical boards containing more instruments, indicating, recording and integrating meters of various kinds, pressure gages, thermometers, draft gages. There were instruments which provided continuous indication of the smoke going up the stacks and there were others which at every instant indicated the exact weight of coal and air being delivered to each of the four pulverized coal burners in the boiler room.



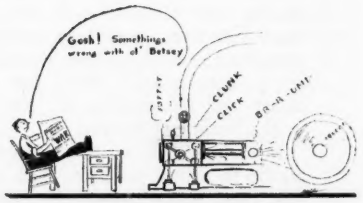
He stood in the central control room

The plant was still unfinished, construction work was still in progress but even at that stage one obtained a good "picture" of what the finished room would look like. With its attractively tiled floor, the streamlined design of the panels, the chromium plated fittings, its effective and efficient system of fluorescent lighting, the room had more the atmosphere of the navigating bridge of an ocean liner than that of a power plant.

From this point the operator, at the mere touch of a button, can control every important operation, anywhere in the plant. Every fan, every pump, every large steam or water valve, every pulverizer feed, every large circuit breaker is subject to his control. The largest valve in the plant—and there are some large ones, I can assure you—can be closed or operated with no more effort than the mere pressure of one's finger on a button.

Yet, in the normal operation of the station, even this slight bit of effort need not be expended for the entire system is under automatic control. The slightest change in load and consequent steam pressure initiates the operation of a score of automatic controllers which adjust fuel and air supplies to conform to the change in load, at the same time maintaining proper ratios between them. The operator's primary function in this plant is to watch and to see that nothing goes wrong. By the turn of a switch, he can shift the control from automatic to manual.

At the time I was gathering data for the article describing this station, which appears in other pages of this issue, but as I stood in the control room I thought of myself as the editor of the Practical Engineer and wondered as I surveyed the complicated array of equipment around me just where the practical engineer "came in" in a station such as this. This elaborate apparatus obviously was installed by skilled technicians and specialists—men of many years experience and training along highly specialized lines. What need was there here for the practical kind of knowledge and skill which makes a man a practical engineer? Of what use was there for the man who, in years past, could tell by the click of the valve gear whether a Corliss engine was running properly and who with equal skill could caulk a leaky seam on an H.r.t. boiler under pressure? In the old days a man put some boiler compound in the boilers to keep the surfaces clean and free from scale and let it go at that, but in a plant such as this the chemistry of the boiler feedwater is so complex that it requires the service of a



Could tell by the click of the valve gear

[1]See page 634.

specialist with a chemical laboratory at his disposal.

The practical man of a few decades ago could tell by the color and finish of the commutator whether the brushes were adjusted correctly; here there seemed to be no commutators, though I later found some on the exciters but even these were enclosed in steel casing, practically out of sight. Everything in this station it seemed rested on complex technical foundations. The startling thing about the superheat control baffles, for example, was not so much the way they were made but that they were made of 27 per cent Chrome steel.

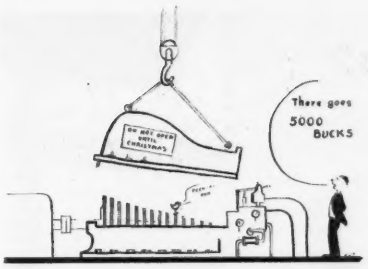
All of which leads up to the rude but expressive modern inelegance, "So What?"

Suppose there is no Corliss valve gear in the modern power plant or no boiler seams to caulk; suppose the valves are controlled from push buttons and that slice bars are no longer the indispensable things they once were? Does the fact that the engineer is relieved of hard physical labor imply that there is less opportunity to exercise his practical knowledge? Does the fact that combustion is controlled automatically make it less necessary that an engineer understand the fundamentals of combustion? And if modern boiler water chemistry does bristle with hydrogen ions and pH values, corrosion is still rust when it occurs on iron and it still must be prevented by methods that really are not difficult to understand. Does the fact that water cooled furnaces have few refractory problems reduce the necessity for sound judgment in the operation of furnaces?

One war ago, when, as has been mentioned before in these columns, I served in the Navy as a neophyte engineer on one of our 90 day speed demons on the North Atlantic, there was an old Norwegian engineer officer who used to deplore my lack of interest in washing down bulkheads. "You'll never be a good engineer" he used to tell me when I failed to take sufficient interest in the washing operations. Despite the fact that his predictions were largely correct, his attitude was wrong. He had nothing but the utmost contempt for the turbine on this ship because he, being of the reciprocating school, could not see anything move, and there was no place on it into which he could poke the spout of an oil can.

The trouble is that too many of us associate the term "practical engineer" with a picture of an old man in overalls with an oil can in his hand. This picture, it is true, at one time did symbolize the engineer, but times have changed and the picture is useful now only in advertisements for railroad watches. Lubricating systems today are mostly forced feed and even the oil can is disappearing—not entirely, but as a symbol.

But what of it? Suppose the operator in the modern plant does wear a white shirt; suppose he doesn't spend his time in a dusty, overheated boiler



It costs $5000 just to open up a turbine

room, or a less dusty but equally overheated engine room, do these facts make him less of a practical engineer? Does the fact that the old order of dust and dirt, heat and oil has given way to an atmosphere of cleanliness and comfort imply that there is no opportunity for the application of what we are pleased to call practical engineering?

Of course not. It is true hand firing involved a certain type of skill and knowledge but it was the type of skill that is associated with most manual labor, and the effort required left very little opportunity for attention to the real engineering problems that come up in a power plant. The operation of modern stokers or pulverized coal equipment requires skill of a different kind but of a higher order, and requires considerably more knowledge of the fundamentals of combustion.

So, too, in the turbine room. A turbine may have no Corliss gear to click but it has a hum and the engineer's perception is just as important in recognizing the variations in this hum as it was in the case of the engine. It is a great deal more important to keep a modern turbine running. As Mr. Neblett of the General Electric Co. pointed out recently, it costs about $5000 just to open up a modern turbine and find out what is wrong with it.

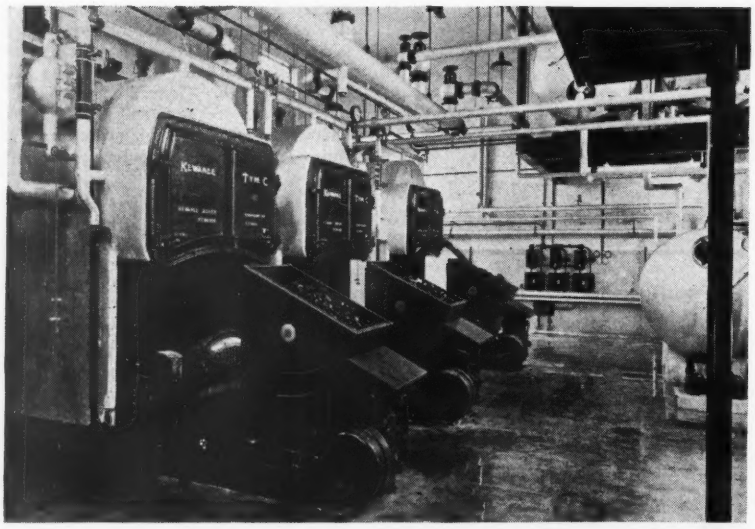
Modern power plant equipment, while not necessarily more complex than that used in the early years of the industry, is designed to closer limits and is based on technical knowledge of a higher order. Its construction and operation require the same sort of practical knowledge that made the old time Corliss operator invaluable.

Consider, for example, the interesting method used to remove the bolts from the holes in the coupling shown in the accompanying photograph. This is a shop view in the Milwaukee shops of Allis-Chalmers taken when they were constructing the coupling for a large hydroelectric generator. It shows the method used in shrinking the tight fitting 4 in. bolts so as to facilitate their removal from their carefully reamed bolt holes. Alcohol cooled by dry ice to 40 deg. below zero, Fahrenheit, is shown being circulated through a hole in the center of one of these bolts. Simple, isn't it? Yet it's practical.

I do not profess to know where this method of shrinking steel originated, whether in the design room or in the shop, but I venture to say that whoever thought of it first was a practical man regardless of the kind of clothes he wore.

A. W. KRAMER.

Shop assembly view of huge coupling for 30,000 kv-a. Chickamauga Dam of TVA in Allis-Chalmers shop. Tight fitting 4 in. bolts are removed from their holes by circulating alcohol cooled by dry ice to 40 deg. below zero F. through holes through the center of the bolts. The tank containing the dry ice and the alcohol may be seen at the left.



BOILER AND STOKERS

Proper Operation of Underfeed Stokers*

By E. C. Webb,

Engineering Service Manager
Iron Fireman Mfg. Co.
Cleveland, Ohio

IT IS EASIER to obtain smokeless operation with some coals than with others, but with a reasonable amount of care, most coals can be burned in underfeed stokers without excessive smoke. If a plant equipped with underfeed stokers is producing objectionable smoke or flyash, it is probably the result of a shortcoming in one or more of five factors: burning characteristics of the coal that is used; boiler or furnace design; design and condition of stoker and auxiliary equipment; application and installation of this equipment; manner in which the equipment is adjusted and operated.

Very often the particular combination of two or more of these factors is responsible for the trouble and a change in any one of them may be sufficient to overcome the difficulty. For instance, a change in either the type of coal or the boiler or stoker design would materially improve the performance, yet reasonable care in handling or distribution of load might be equally as effective. Ordinarily, it is not practical to make major changes in boilers or furnaces in existing plants.

Before recommending major changes in the plant, it is well to make a thorough analysis to definitely determine if the equipment as installed could be so adjusted and operated that it would not produce objectionable smoke when burning the type of coal that the owner prefers to use. Stoker design is, of course, an important factor, but if properly applied and operated, most of the machines now on the market will give creditable performance. The condition and maintenance of the equipment is equally as important as the original design. Adjustment and operation of underfeed stokers is now quite generally understood, but, since it plays an important part in the reduction of smoke, a list of some of the most important points to be considered are given in the table.

Check list of points to consider in operation and installation of stokers

1. Available Air Supply.
   - A. Is boiler room properly ventilated?
   - B. Are forced draft fans running at proper speed?
   - C. Fans, air ducts, plenum chambers, and tuyeres should be in good condition, clean and free from obstructions.
2. Coal Feed and Air Regulation.
   - A. Adjust for proper depth of fuel bed and complete combustion.
   - B. Do not shovel coal into the furnace.
   - C. Do not slice or otherwise disturb fuel bed unnecessarily.
3. Draft in the Combustion Chamber.
   - A. Adequate draft must be available to handle peak loads.
   - B. Breechings and stacks should be clean and in good repair.
   - C. Adequate means for regulating draft.
4. Getting Fuel Bed and Furnace in Condition to Meet Load Demands.
   - A. Allow ample time to build up fuel bed and furnace temperature.
   - B. Study load cycle for improvement.
5. Cleaning the Fire.
   - A. Proper scheduling of cleaning periods.
   - B. Turn off stoker and close stack damper when cleaning.
   - C. Disturb fuel bed as little as possible.
6. Cleaning Flues, Breeching and Stack.
   - A. Clean regularly all places where ash may accumulate.
   - B. Close breeching damper when cleaning flues or boiler setting.
   - C. If tubes are blown with steam or compressed air, use a wet-down spray in the stack.
   - D. Ash accumulations in the base of stack should be wet down before they are removed.

Proper adjustment and operation of an underfeed stoker is not a difficult job, but the problem of training a fireman sometimes resembles that of trying to "teach an old dog new tricks." A man, who has fired a boiler by hand for a great many years, often has difficulty in getting away from the habit of unnecessarily slicing the fuel bed or occasionally shoveling some coal into the furnace. In other cases, the stoker supplier has failed to properly instruct the fireman, in fact, this is probably the most frequent reason for improper adjustment and operation.

Occasionally a fireman, who is naturally careless or lazy, will stir up the fly ash in the breeching or the base of the stack, so that it will be discharged over the neighborhood, rather than taking the time to clean it out in the proper manner, or, he may insist on carrying extremely thin fuel beds, resulting in excessive fly ash carryover, because the fire is easier to clean.

Improper adjustment and operation is without question one of the principal reasons why some plants that are equipped with underfeed stokers produce objectionable smoke. This problem presents a real challenge to the stoker manufacturers and distributors to do a more thorough job of instructing and training the operators of their equipment.

Banking Boilers

IN ORDER TO take care of peak loads which may occur once or twice a day, one or more boilers must be banked, that is, kept hot with the fire burning slowly so that they can be put quickly on the line.

When banking a boiler, the forced draft should be shut off and the forced and induced draft fans stopped before the fuel feed is stopped. In case of a light stoker fire at the time of banking, the stoker should be turned two or three revolutions approximately every hour during the banking period. The exact number of revolutions depending upon the individual stoker. The stack damper should then be closed until the opening is just sufficient to clear the furnace of gasses and the main feed valve to the boiler should be closed.

When a stoker fired boiler is ready to be put back on the line, the water column and gage glass should be blown down and checked by opening the gage cocks. Water should be maintained at about the same height as when putting the boiler on the line from a cold start. Superheater drain should be opened wide and allowed to remain open until the superheater is thoroughly drained and the boiler on the line.

Ashes should be winged back on the clinker crusher if there is one or the dump plates should be dropped and then closed if there is no clinker grinder. When hand dump plates are used, the lower ram of the stoker should be put on long stroke and the draft on the extension grate shut off. The boiler valves should be operated manually until the steaming rate is such that the feedwater regulators will operate satisfactory, at which time the feedwater valves should be opened wide. With a short bank, it is not nec-

*From a paper presented at the 33rd Annual Convention of the S.P.A.

essary to adhere to the above procedure but it is advisable to maintain not more than one gage of water.

With pulverized fuel units water column and gage glass should be tested as before and the superheater drains opened. Afterwards induced and primary air fans can be started and some of the burners lit, more burners being added according to the plant schedule and upon length of time allowable for the boiler to go on the line. Feedwater should be controlled manually until the steaming rate is such that the feedwater regulators will operate satisfactory. After the regulators are in service the feedwater valves should be opened wide.

Care and Maintenance of Boilers

EXTERNAL CLEANING of boilers in connection with inspection or routine care and maintenance should be started by blowing the soot from the boiler and superheater tubes and exposed surfaces of the drums with compressed air or dry steam. They should also be cleaned of all clinker formation and the clinkers removed from the walls of the furnace in a careful manner so as not to injure the brick work.

Combustion and soot chambers, air duct undergrate air and water back compartments should also be cleaned and the dampers examined. The brick work, arches, baffles, piping and bolts should be inspected and repaired and the air openings in the grate surfaces cleaned and castings replaced where necessary. Exterior surfaces of the boiler can be painted with a suitable paint to advantage.

Men working on the boiler should report any leakage or indication of leakage in joints or where tubes enter the header or drum.

Internal Inspection

Before entering a boiler, take precautions against steam and blowoff valve leakage and the presence of poisonous gases. When turbining the tubes the blowoff pipe should be screened or blocked so that scale will not go down the blow down piping. The machine should be inserted in the end of the tube before starting and after it has entered about 1 ft. water should be fed into the tube behind the cutter and the machine fed backwards and forwards, making a gradual advance, the operation being repeated until the tube is clean. Afterwards a follower should be used to determine the proper gage. After the tubes have been bored clean, they should be washed out with water or blown out with compressed air and the scale removed from the drum or header base.

Dry pipes and internal feed pipes, as well as all interior surfaces of drums should be inspected and cleaned when necessary. Owing to sharp curves and the presence of core in some types, superheater tubes are difficult to clean. Those with no core can be cleaned by a wire cable stubbed on the end. Afterwards they should be blown out entirely with compressed air.

Hydrostatic Test

After the internal surfaces have been scaled, and washed out, the blowoff pipes should be unblocked or unscreened, the handhole and handhole covers and bolts, replaced, the boiler closed and filled with about 90 deg, F. water preparatory to a hydrostatic test. During this test the automatic non-return valve should be blanked-off and the safety valve clamped down. After completing the test the boiler should be drained to normal water level and blanks and clamps removed.

Water column fittings and connections should be inspected at least annually and overhauled if necessary. When gage glasses are replaced, see that there is no metal to glass contact or twisting strain and that the glasses are replaced directly in line. All valves, blowdown lines, safety valves, pipe and drum coverings should be inspected at least annually.

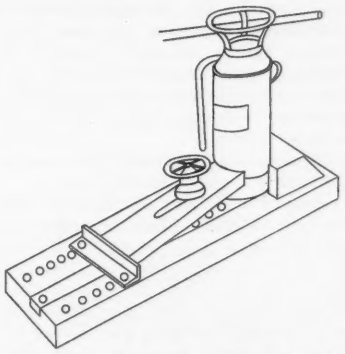
Economizers should be considered as boilers and given the same inspection and cleaning, and if the tubes are uncapped, they should be carefully inspected for internal pitting.

PRACTICAL HINTS AND KINKS

Floor Vise

By Chas. H. Willey

FOR THE gripping of large bulky work there is often a need for a device to do it handily. Such a floor vice can be easily made from a piece of plank and a few odds and ends such as a bar of iron drilled and tapped and set into the plank, for the use of the gripping stud.



A piece of angle iron with two pins is used as the back jaw with a series of holes to make it adjustable. The clamping pressure is obtained by the piece of plank A, which is slotted to make the adjustment of it on an angle. The sketch shows it being used to hold a shop fire extinguisher while unscrewing the head, but it will be found useful for a wide range of work.

How to Use Wrenches

By N. G. Near

I WISH to add an important point on the use of wrenches to those listed on page 541 of the August issue of POWER PLANT ENGINEERING, and that is, don't *lengthen* your wrench if you are doing an important tightening job.

Too often I have seen men "slip a gas pipe over" on a wrench handle, thereby making the handle longer and increasing the leverage, which is poor and unsafe practice.

Wrench lengths for small nuts are invariably short; for medium nuts, medium in length; and for large nuts, they are long. In manufacturing wrenches everything is considered: pitch of the thread, cross-sectional area of the bolt at the bottom of the threads, and the average strength of the man who does the tightening.

To make a wrench "twice as long" you therefore increase the tension of the bolt to twice the amount, the force of pull on the wrench being the same. By increasing wrench lengths I have several times actually "stretched" bolts until they broke in two, or I have stopped turning as soon as I felt the bolt begin to stretch. This is very poor practice, of course.

If you feel like making a wrench longer for "unscrewing" a nut—all right. But don't lengthen a wrench when tightening.

No. 15 says, "Never use a wrench as a hammer." I would qualify that because some readers might be led to think that a wrench shouldn't even be used for light tapping. Monkey wrenches are made with a sort of hammer head indicating that it is perfectly all right to use a monkey wrench for hammering to a certain extent.

One of my foremen used to be very strict about little things like using a wrench as a hammer. Whenever a light and loose pipe spacer was a trifle out of line, and a man would tap it gently with an S-wrench to put the spacer where it belonged, the foreman would shout (if he caught the man at it) "Hey there, you! A wrench isn't a hammer!" As a result a vast amount of time was wasted changing from wrenches to hammers and back again. He would not allow a man to use a shovel for prying no matter how slight the force required because, as he said, "A shovel isn't a crow-bar." Yet, as a matter of fact, shovels are combination shovels and crow-bars in tie-tamping operations in railroad maintenance work and in nearly every other kind of work.

Some fussy draftsmen say, "Never use a scale as a straightedge because a scale isn't a straightedge." I have never been able to understand why. My pet slide rule has been in use for 30 years now and I have *always* used it as a straightedge whenever I felt like it.

Brass Fittings

By P. F. Rogers

BECAUSE brass and bronze fittings and pipe are not used as widely as they used to be, most plants have a supply lying around on the scrap pile and they often come in handy to use where a little extra trim is desired. They are apt to be pretty greasy and dirty, however, which rather discourags their use. They can be easily cleaned with little or no work and with a small expenditure of time.

If their condition is very bad, make up a solution of 20 per cent nitric acid, 78 per cent water and 2 per cent of aluminium sulphate; when not so bad, a 10 per cent solution of caustic potash, or common lye as used for household purposes will answer the purpose.

After they have been cleaned in the solution they should be washed thoroughly, preferably in running water and then dried at low temperature. An electric heater is satisfactory. If a blow torch is used the drying should be done through a piece of sheet iron so that they do not get the flame direct. After being cleaned and dried they should be polished with any good grade of brass polish. This is not necessary but is advisable, for it forms a protective coating which helps keep then clean and to a certain extent retards corrosion. and discoloration.

FOR THE PLANT ELECTRICIAN

Testing Electric Circuits With a Flashlight

By Eugene George Key and Michael J. Coppola

GROUNDS are probably the most common troubles encountered with electric wiring of any kind, particularly if the wiring is installed by inexperienced hands. Wiring installed by experts is also very apt to become grounded or even shorted or opened if any moving apparatus is involved or if the wiring runs are in wet, damp, or extremely hot places.

Of course, when trouble of this kind occurs, it must be located before it can be repaired, and the only way to locate any fault without actually removing the wires is to test them. The best way to test any circuit is, of course, with a reliable test set of some sort, but these are not always available. One alternative method is to use a flashlight with a good bulb and battery.

The first step in testing with a flashlight is to "kill" the circuit on which the fault is present. Remove the fuses, or, if necessary, disconnect all wires between the circuit and all sources of supply. This must be done, as nearly all lighting and power circuits are grounded at the transformer or at the main service switch. This grounded connection is usually in accordance with the law. To test the faulted circuit without opening all connections to this ground will cause erroneous indications.

The second step is to remove any grounded equipment from the circuit. Occasionally, the neutral of a motor or other equipment will be grounded at the machine and if it is, erroneous indications will again result. These two rules should be observed regardless of the method used in testing.

Remove the end of the flashlight opposite that of the bulb so that the flat end of one of the cells is exposed. The lens may also be removed from the bulb end so that the tester may see more clearly when the bulb lights during the test. When the bottom of the flashlight has been removed the flashlight switch is then closed so that the only open circuit between battery and bulb is between the case and the leaded part of the lower cell. The flashlight is now ready to be used as a testing set for grounds, short circuits, or open circuits.

The method to be used for testing for these three kinds of faults follow:

Grounds. Holding the flashlight with the bulb end down, place the edge of the case against a pipe, preferably the conduit, BX, etc., containing the wires to be tested, but be sure that only the case touches the pipe. Then place one of the wires against the leaded part of the cell. If the bulb lights, the circuit is grounded. Whether it lights or not, test all wires leading to the circuit, as more than one may be grounded.

When all wires have been tested in this manner and show definitely that the circuit is grounded, the next step is to locate the approximate place where the fault is. Sometimes, particularly in wires involving several lights or other equipment, there are other outlet boxes than the one at which the first test was made. Go to the next successive box and open the splices there. Unless this is done, no matter where the ground is, the bulb will light. By opening the splices, the tester can find exactly which wire is faulted. All splices should be opened in order until the faulted wire is found. This wire can then be replaced and the circuit restored to normal without further molesting any other part of the circuit.

Short Circuits. In testing for short circuits, all equipment must be disconnected. If a lighting circuit is involved, the easiest way is to remove all lamps in the circuit. With the circuit known to be open at all places where it is normally closed by the wiring in the equipment on that circuit, go to the outlet box nearest the sourcue of supply, place one wire of the circuit against the case of the flashlight and another against the leaded part of the battery. If the bulb lights, the cirsuit is shorted. As in testing for grounds, open all splices in all outlet boxes through which the circuit runs and test the wires in ever box until the faulted wires are located.

Open Circuits. Remove all equipment connected to the circuit except one, preferably that nearest the box in which the test is to be made. The circuit is then closed through that equipment unless an open circuit is present in the wiring through that equipment. Place the wires on the flashlight as in the test for short circuit. If the flashlight bulb lights, the circuit is complete to that equipment. Connect a second piece of equipment into the circuit and remove the first, and test again from the same box as before. By following this procedure, the faulted part of the circuit can be found very easily.

If the flashlight used has an insulated case, one cell and the bulb should be removed, as the tests cannot be made as described if the case is insulated. Place the point of the bulb base against the small contact at the top of the cell, the leaded part of the cell against the pipe or one of the wires and touch the other wire to the threaded part of the base of the bulb. The bulb will not light as brilliantly as it would in the tests involving all flashlight cells, but it will be bright enough to indicate the condition of the circuit.

Carbon Brushes

By S. H. Coleman

MAKE OF MACHINE, service requirements and numerous other factors all must be given consideration when selecting carbon brushes for plant motors and generators. Not only must brushes fit the holders but characteristics such as hardness, abrasiveness, peripheral speed limitations, current carrying capacity, specific resistance, contact drop, etc., must be carefully balanced to obtain the particular combination of qualities making up the grade of brush material needed to give reasonably long and satisfactory service in a given application. With these facts in mind it is obvious that grade recommendations are best obtained from the brush manufacturer who has the necessary research and laboratory facilities for their accurate determination.

INSTALLATION

1. See that brush studs are in alignment and brush holders are in good condition. Holders having slightly burnt or worn inner surfaces can be smoothed up with a file. Badly damaged holders should be replaced.

2. Make sure that brushes fit the holders snugly. If too loose, tilting in the direction of rotation may occur so that correct bedding is impossible. If too tight, sticking and poor response to spring pressure are likely to be experienced.

Expansion of the brush when heated must also be given consideration, especially if the graphite type is used. It is best when ordering brushes to specify the internal dimensions of the holder so that the manufacturer can determine the proper brush size.

3. Fasten pigtails in place making sure that screws are tight so that there is no danger of the pigtail working loose and damaging the ring or commutator.

4. Cut a strip of coarse sandpaper the width of the ring or commutator and long enough to cover its circumference with a slight over-lap and place it around the contact surface with this overlap pointed away from the direction of rotation.

5. Secure the sandpaper in position with tightly bound string at its outer edges or with some adhesive that can be easily removed when the job is done.

6. Place the brushes in position; checking again to see that they fit properly and are aligned correctly.

7. With brush springs at full pressure revolve the armature with some external source of mechanical power or by hand if necessary until the contact faces of the brushes have a curvature approximately corresponding to the contour of the metal surface.

8. Remove the coarse sandpaper and finish each brush separately by hand using fine sandpaper. Finishing should only be done in the direction of rotation; lifting the brushes away from the abrasive action during the return stroke. Single brushes can be bedded in by hand with this same procedure by using a strip of coarse sandpaper first.

9. After brushes are bedded in, blow out all carbon dust with dry compressed air, a portable blower or hand bellows.

10. Reset springs to the pressure recommended by the manufacturer, or if this is not at hand, to the lightest pressure that will give proper contact without sparking or excessive heating.

11. Check pigtails to see that they will not hinder brushes from feeding properly and start up the machine.

12. With the machine running; make any necessary adjustments of spring pressure that may be required to prevent sparking or heating and closely observe brush performance until you are satisfied that everything is in good order.

Note: Under no condition substitute emery paper or other abrasive sheeting for sandpaper when bedding in brushes. When particles of these hard materials become imbedded in the metal, sparking and rapid wear of brushes will result. Since many abrasives of this type are also partial conductors they are likely to cause short circuits, especially when used on commutators.

Troubles

The principal symptoms of brush troubles are sparking, heating and rapid wear either singly or associated in varying proportions. Sparking however, is often found by itself while heating and rapid wear seldom occur alone. Among the troubles indicated by these symptoms are:

(a) *Sparking:*

1. Dirt, oil, corrosion or other foreign material on brush contact surfaces, collector rings or commutator.
2. Free movement of brushes in their holders prevented by oversize brushes, dirt, or roughened internal surfaces of the holder.
3. Spring pressure too light causing poor contact.
4. Spring pressure too heavy resulting in heating due to friction and poor commutation.
5. Brush studs out of alignment.
6. Rocker in wrong position.
7. Rough commutator ring surfaces which may be either the cause or result of sparking.
8. Jumping of brushes caused by rotor unbalance or other vibration.
9. Improper brush bedding caused by faulty installation, a loose brush stud, brushes too small to fit their holders or worn holder boxes.

(b) *Heating:* All brushes heat equally.

1. Overload on machine.
2. Brushes of too low current carrying capacity.
3. Excessive friction on all brushes due to too much spring pressure.

(c) *Heating:* Some brushes heat while others do not. This is usually the result of unequal distribution and may be caused by one or more of the following factors:

1. Loose or misaligned brush studs.
2. Improper bedding.
3. Mixing different grades or sizes of brushes on the same machine.
4. Differences in pressure on various brushes.
5. Loose connections on brush rigging.
6. Short circuits or open circuits in the machine itself.

(d) *Rapid brush wear:*

1. Excessive sparking.
2. Excessive heating.
3. Too much spring pressure.
4. Brushes too soft or oil soaked.

Maintenance

a. Inspect brushes daily and correct any tendency to spark or heat. If correction cannot be made while the machine is running make a note of the condition and perform needed adjustments whenever the unit can be removed from service, remembering brush troubles are cumulative and the sooner corrected the less damage experienced.

b. Clean contact surfaces as often as may be necessary to avoid troubles caused by oil, corrosion, or dust.

c. At regular intervals check tightness of studs, stud alignment, cable connections, pigtail connections, wear of brushes and holders, and load on the machine.

d. See that commutator or rings are smoothed down and trued up when necessary. Keep mica insulation between commutator bars undercut sufficiently to avoid trouble from this source.

e. Check resistance of machine windings from time to time to detect conditions that might result in current unbalances.

Preventing Corrosion of Underground Cables

By Charles C. Lynde

Petroleum jelly, No. 3 cup grease, or any other lubricant derived from petroleum is only indirectly to blame for the corrosion of underground cables, as mentioned by Mr. W. E. Warner (page 603, your September, 1939, number). The corrosion is caused by condensation of atmospheric moisture on the cables as they lie in conduits. This moisture, forming as a thin film over the surface of the cable, tends to assume the shape of small droplets, due to the effect of surface tension. Under this same force, the droplets progress across the surface covered by the grease, traveling until they reach a "holiday" or spot not grease-protected. Here the drops stop, supplying the moisture needed for activating oxidation or corrosion.

This spotty corrosion can be traced to the *un*-greased spots by careful examination of any such cable after being drawn from a conduit if the mechanical action of removal has not blurred traces past recognition.

This localizing of corrosion on cables in conduits on shipboard when petroleum lubricants were used for running the cables at time of replacement led to a series of experiments to determine some method which would inhibit oxidation, or at least prevent the localization of wet spots at the edges of lubricated areas.

The method developed hinged upon the successful blocking of air currents through the conduits; as it is only through renewal of the air-borne moisture that water condensation can collect in quantities sufficient to cause corrosion.

One end of the conduit (preferably the less accessible one) was sealed with resin or some of the more easily obtained plastics; and a tee and riser let into the conduit, or the opposite end given a short vertical section and this filled with a good grade of hard grease. This plug, worked into the conduit for a distance of a foot or more, could yield slightly with expansion or contraction of the air trapped within the conduit, yet maintain a moisture-proof seal between cable and tube.

Cables thus sealed into conduits could be removed by melting the hardened resin seal and then pulled as usual. The same method of sealing cables has been widely used in protecting power leads to pumping installations in the oil fields.

A most satisfactory lubricant (*provided* the installer is *sure* he will not be required to pull the leads later) may be compounded from a pound of either white-lead or red-lead paste worked into a quart of boiled linseed oil. This paste is corrosion-inhibiting, and lubricates well; but once the linseed has dried and become hard, the cable will pull in two before the long grip between cable and tube is broken.

ANNOUNCING ANOTHER PRIZE

Beginning, at once, we are offering 3 prizes in this contest instead of the 2 heretofore awarded. From now on there will be a First Prize of $15.00, a Second Cash Prize of $5.00 and a Third Cash Prize of $2.00. The rules of the contest remain the same.

How Would You Do It?

THE PUMP PROBLEM presented as Problem No. 2 in the August issue brought forth a large number of replies and by this time there need be little room for doubt in our hero's mind as to what to do. The problem, as will be recalled, considered the possible removal of a pump from a point near a cistern to the boiler room. Overwhelmingly, the replies advised our hero not to move the pump—unless. Unless what? Well, unless certain conditions prevail which he did not mention in stating the problem. Our hero's failing, it seems, is never to give full information in stating his problems.

In this particular case, the one important thing he failed to state was whether the exhaust steam from the pump was being utilized in some fashion or if it was not being utilized in the present location; whether the removal of the pump to the boiler house would permit its use. If the latter, the removal of the pump to the boiler room most certainly would be desirable since the value of the recovered exhaust steam would more than pay for the costs involved in effecting the change.

If the pump were moved under these conditions, that is, if by the change in location the exhaust steam could be recovered and used, it would be necessary to use larger piping than that considered in the statement of the problem.

Our hero, it will be recalled, considered the use of a 4-in. suction line and a 3-in. discharge. As nearly all of the replies pointed out, however, with long lines of such small size, the friction heads introduced would be so high that the pump could not operate. As the prize-winning answer points out, theoretically, with 60 deg. water the maximum suction lift for a pump is 33.4 ft. with normal barometer. In practice, however, this value is never reached and even under favorable conditions a lift of 26 ft. is about all that can be expected; for good operation and minimum trouble, a smaller suction head should be provided.

It is quite obvious, therefore, that if this pump is moved to the boiler room, larger lines should be installed, at least a 5-in. suction and a 4-in. discharge, although some replies specified a 6-in. suction and a 5-in. discharge. In any event, if the exhaust steam is not being utilized in the present location near the cistern, but can be utilized if the pump is moved to the boiler room, the value of the recovered exhaust steam will more than pay for the costs involved in making the change.

While nearly all the replies to the problem consider some of these angles, only one really considers all of them. This is the letter sent in by Barry M. Turner of Ticonderoga, N. Y., to whom we award the first prize. Mr. Turner's analysis of the problem, as will be noted, is clear and concise and he takes all aspects of the question into consideration. First, he shows that insofar as the reduction of radiation loss is concerned, nothing would be gained by moving the pump. This removal would cost some $625. Next, he points out that if such a change were made, it would not work, due to the increased friction head. Then he shows that it could be made to work by substituting larger lines—4 and 5 in. lines, at a total cost of $755. Finally, he takes up the question of using the exhaust steam and shows that if this can be done, the suggested change, using 4 and 5 in. lines will pay handsome dividends.

Curiously enough, honors for the second prize again must be shared by two men, one C. O. Sandstrom of Los Angeles, Cal., and the other Julius Brodsky of Rochester, N. Y., who, incidently, also won second prize in last month's contest.

Both Mr. Sandstrom and Mr. Brodsky, probably, understood all the conditions involved in the problem just as well as Mr. Turner, but they are not quite as explicit in stating them. Mr. Sandstrom assumes that the exhaust is returned to the boiler. With this assumption, it is quite obvious from his calculations that any savings in heat loss that might be obtained from making the change, would be far too small to warrant the expense of making the change; furthermore, he takes into consideration the high friction heads.

Mr. Brodsky's letter, again is very thorough and while his figures differ somewhat from those of the others, he nevertheless arrives at the same general conclusions. He suggests the use of a 5 in. discharge and a 6 in. suction line, but he is less definite than Mr. Turner in regard to the use or non-use of the exhaust steam.

Quite a number of the letters pointed to the advantage of installing an electrically driven pump. Depending upon circumstances this might be the most desirable thing to do, but before this is recommended all the other conditions of the problem should be analyzed.

FIRST PRIZE AWARD

PROBLEM II

By Barry M. Turner

Before advising our hero to change or not to change the location of the pump, let us first estimate the extent of the heat loss from the 100 ft. of steam line. If we assume that the supply line is 1¼ in. and an average outside temperature of 45 deg. F., a 2½ in. covering of 85 per cent magnesia properly protected from the elements will have a heat loss of 0.382 B.t.u. per sq. ft. of pipe surface per hr. per degree temperature difference between pipe and air. The heat loss per hr. will be—

$$44 \times (324 - 45) \times 0.382 = 4690 \text{ B.t.u.}$$

In a year of 300 working days, this will amount to approximately 33,800,000 B.t.u. Since the line is outside and subjected to moving air currents, an additional 10 per cent should be added. This makes a total heat loss of 37,180,000 B.t.u. per year, which represents a heat equivalent of 31,370 lb. of 80 lb. steam. Assuming it has a fuel value of 30 cents per 1000 lb., this loss has a value of $9.41. Certainly, for a saving so small, it would not be good economics to move the pump.

We will, however, investigate the suggestion of moving the pump to the boiler house and running approximately 400 ft. of 4 in. suction and 3 in. discharge line. Assuming a minimum of fittings and that the pipes are buried in average soil, it is estimated that this would cost approximately $625.00.

We will assume also that the pump is a duplex, reciprocating type, having an overall efficiency of 85 per cent. The power required to pump 250 g.p.m. against a 70 ft. head will be—

$$\frac{250 \times 70 \times 8.33}{33{,}000 \times .85} = 5.2 \text{ hp.}$$

In its new location the pump will, in addition to the original 70 ft. head,

be required to pump against the pressure loss in the 400 ft. suction and discharge lines. From tables based on Williams and Hazens formulae, there will be a pressure drop of 17 ft. for the 400 ft. suction line and 67 ft. for the discharge line, making the total head the pump will now be required to pump against 154 ft. This is more than double the original head and will require a proportionate increase in power, namely—

$$\frac{200 \times 154 \times 8.33}{33{,}000 \times .85} = 11.42 \text{ hp.}$$

It is indeed fortunate that 130 lb. steam is available in the new location, as it will no doubt be needed because of the increased power required. Even with this pressure, unless the pump was liberally designed, there may be some difficulty in obtaining full capacity. As the pressure losses were based on new pipe they will, as the pipe continues in service, increase in magnitude because of rust and deposits—thus requiring the pump to do even more work.

In regard to the discharge line, it will be found that at 250 g.p.m. the water would have a velocity of 11.38 ft. per second. Good design usually limits this value to 10 ft. per second. Hence, if such a line were built, a 4 in. discharge line should be installed. This would bring the pressure drop to a more reasonable value of 17 ft.

Some thought should also be given the 4 in. suction line, even though the velocity is within the recommended limits. With water at 60 deg. F. the maximum theoretical suction left for a pump is 33.4 ft., with a barometer of 29.92 in. However, in practice this value is never reached. Under favorable conditions a lift of 26 ft. is accomplished but for good operation and minimum trouble the suction lift should be as low as possible. The pressure loss tables indicate that as the pipe becomes older the maximum values with the 4 in. pipe will be exceeded.

The successful operation of the pump in question with a 4 in. suction line will depend on whether there was a suction lift in its original location and whether or not the new location is above or below the original installation. At any rate, the maximum net suction head at the pump should not exceed 23 ft. For the small additional expense involved, it would be well to increase the suction line to 5 in., which would give a head loss of only 5.5 ft.

From the above, there is nothing to justify moving the pump—to do so in order to save the heat loss in the steam supply line would be an extremely unprofitable venture.

The foregoing conclusion is based on the assumption that the steam exhaust from the pump is profitably utilized. If it is wasted, and could be absorbed in the boiler house, the pump could be moved at a nice profit. Under the condition of the pump exhausting to atmosphere and steam at 30 cents per 1000 lb., the pumping operation costs approximately $1300 per year.

With the pump in the boiler house and with a 5 in. suction and 4 in. discharge line with the exhaust steam profitably utilized, the heat equivalent of the work done in pumping represents approximately $63.00 per year. Interest and depreciation of the lines represent about $83.00 making a total of $146.00 per year, chargeable to the pumping operation. For an investment of $755.00 for the change, the return is most satisfactory.

I would suggest that our hero check up on conditions and get some data together before he makes his final decision.

SECOND PRIZE AWARD

Problem II

By Julius Brodsky

In this problem we have a pump delivering 250 g.p.m. against a 70 ft. head, since it is not stated whether this is the static head or the total dynamic head it will have to be assumed that this is the total dynamic head against which the pump is working. In the absence of any further information it will have to be assumed that the pump is in operation 24 hr. daily throughout the year.

The water horsepower of a pump =

$$\frac{\text{G.P.M.} \times \text{head in feet}}{3960}$$

for this pump $\text{W.HP.} = \frac{250 \times 70}{3960} = 4.4$

Pounds of dry steam used per w.hp. per hr. for a pump with a 12-in. stroke and 80 lb. boiler pressure = 103. Steam used per hr. will then be $103 \times 4.4 = 453.2$ lb.

Total steam used per year will be 3,970,000 lb.

To find the amount of steam condensed in the line to the pump, since the size of this line is not stated, it will be necessary to estimate the size which will be 2½-in. pipe.

The heat loss from the pipe may be expressed as follows:

$$H = A \times K \ (T - t)$$

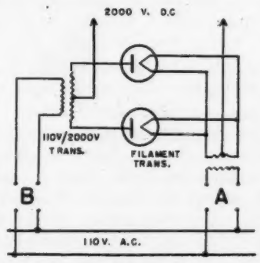
where H = heat loss in B.t.u's per hr. A = area of pipe in sq. ft., for 100 ft. of 2½ in. pipe = 75 sq. ft. K = coefficient of heat transmission, for a pipe in still air this is usually taken as 3, since this pipe is exposed to wind and weather 5 would be a better value. T = temperature of steam in pipe = 324 deg. F. t = temperature of surrounding air which is taken as 47.5 deg. which is the mean annual temperature in this latitude. Then $H = 75 \times 5 \ (324 - 47.5) = 62{,}212.5$ B.t.u.'s per hour. The latent heat of steam at 80 lb. pressure = 891 B.t.u's. The amount of steam condensed per hr. will then be

$$\frac{62{,}212.5}{891} \text{ or } 75 \text{ lb. per hr.}$$

The total amount of condensation per year = $70 \times 8760 = 613{,}000$ lb.

Under present conditions the total amount of steam per year will be 3,970,000 lb. + 613,000 lb. = 4,583,000 lb.

In considering the proposition of moving the pump to the boiler room we find by consulting hydraulic data that: for a 3-in. pipe with a discharge of 250 g.p.m. that the velocity is 681 ft. per min. and that the head loss in feet per 100 ft. is 27.1 ft. and for 360 ft. is 97.56 ft. For a 4-in. pipe with a discharge of 250 g.p.m. that the velocity is 382.8 ft.



Problem No. 4

This month our hero is puzzling over an electrical problem, put to him by the factory superintendent. For certain test work they have installed a small high voltage rectifier which supplies a small amount of direct current power at 2000 v. It is a conventional unit consisting simply of a high voltage transformer, two hot cathode mercury vapor rectifying tubes and a small transformer supplying 2½ volts to heat the filaments. The circuit is shown in the diagram. All this is conventional and one need have no knowledge of tubes to solve the problem. ¶ In the operation of this unit it is essential that switch A be closed before switch B, otherwise high voltage will be impressed on the tubes before the filaments heat up and the tubes may be damaged. So an arrangement is desired which will make it impossible to connect the 110/2000 volt transformer to the line without first closing switch A. Switches A and B are small switches mounted on opposite sides of a test panel and cannot be interlocked mechanically. So our hero has been asked to work out a circuit which will make it necessary for the operator to close switch A, first and then switch B. His first thought was the use of a time delay relay which would automatically close B after A but these are too expensive to justify their use here. He has been wondering, therefore, if he cannot devise some other, simple way out. The switches A and B can be of any type desired, D.P.S.T., D.P.D.T., etc., but magnetic interlocks or contactors are to be avoided. What would you do in this case?

per min. and that the head loss in feet per 100 ft. is 6.7 ft. and for 360 ft. is 24.12 ft. The total head on the pump would then include the present head of 70 ft. plus the head loss in the discharge and suction pipes or $70 + 97.56 + 24.12 = 191.68$ ft. With this great increase in head the steam consumption instead of being decreased would be increased about two and one-half times.

The maximum practicable suction lift at 60 deg. F. is generally taken as 22 ft. and since the pump is taking water from a cistern there must be some suction lift at present, the increase in suction head would make it impossible to operate the pump. The allowable velocity in an intake pipe is usually 200 f.p.m. and for a discharge pipe 500 f.p.m. the velocities obtained with a 3-in. discharge and a 4-in. suction line are too high for good operation. Therefore the proposition of moving the pump using 3-in. discharge and 4-in. suction is impracticable.

Checking the performance of the pump with various sizes of suction and discharge lines we find that the most suitable sizes would be a 5-in. discharge and a 6-in. suction line. Then for a 5-in. pipe the loss in head per 100 ft. is 2.24 ft. and for 360 ft. is 8.1 ft. And for a 6-in. pipe the loss in head per 100 ft. is 0.93 ft. and for 360 ft. is 3.35 ft. The total head would then be $70 + 8.1 + 3.35 = 81.45$ ft.

$$\text{the water hp.} = \frac{250 \times 81.45}{3960} = 5.14$$

With 130 lb. boiler pressure the steam consumption would drop to 93 lb. per w.hp., then total team per hr. would be $5.14 \times 93 = 478$ or 4,187,000 lb. per year. The amount of steam saved per year would then be 4,583,000 lb. minus 4,187,000 lb. or 396,000 lb. Assuming steam cost 50 cents per 1000 lb., annual saving will be $198.00.

Since both lines will have to be laid underground to prevent freezing in cold weather, the installation cost would run about $3.00 per ft. or approximately $1000 for the job. It is very doubtful whether this proposition would appeal to the management as a good investment.

In figuring condensation loss in pipe it was assumed that the pipe was uncovered, a saving of at least 80 per cent can be made by covering the pipe, or an annual saving of 80 per cent of 613,000 lb. or 490,000 lb. which at 50 cents per 1000 lb. would amount to $245.00.

Consideration might also be given to the use of a motor driven pump. Assuming a pump efficiency of 70 per cent and motor efficiency of 80 per cent, then with the present water hp. of 4.4 it would take 8 b.hp., or a power input of 6 kw. On an annual basis total consumption would be 52,560 kw-hr. and at 3 cents per kw-hr. this would cost $1606.80 which represents a saving of $684.70 over the present cost of operation.

It is the judgment of this writer that the wisest procedure would be to first do a good insulating job on the steam line to the pump and then investigate the cost of an electric pump installation.

Since power rates vary widely the above rate in all probability will be rather high, industrial plants that are already large power consumers usually enjoy a much lower rate, for instance local rates to industrial power customers (Rochester Gas and El. Co.) are $2.00 per kw. per month of max. demand and 0.7 cents per kw-hr. energy charge making the annual bill $511.92, this would represent an annual saving of $1779.58.

The probability is that electric rates will fall somewhere between the two rates mentioned above and that the pump is not actually in operation at full capacity during the full 24 hours, but the purchase of an electric motor driven pump seems by far a more profitable investment than moving the pump to the boiler house.

DUPLICATE SECOND PRIZE AWARD

Problem II

By C. O. Sandstrom

If the change were made as suggested in Problem No. 2, the velocity of 250 g.p.m. of water through a 3-in. std. discharge pipe would be 10.9 f.p.s. and, with a friction factor of 0.0233 for a clean pipe, and a length of 360 ft., the friction head $h_f = \frac{flv^2}{d2g} = \frac{0.0233 \times 360 \times 10.9^2 \times 12}{3.068 \times 2 \times 32.16} = 60.6$ ft., or 26.25 p.s.i. The friction head in the 4-in. suction pipe with a velocity of flow of 6.3 f.p.s. and a friction factor of 0.0242 would be $\frac{0.0242 \times 360 \times 6.3 \times 12}{4.026 \times 2 \times 32.16} = 16$ ft. of 6.93 p.s.i. The friction head in the suction line, plus entrance head, plus velocity head, plus the head produced by fittings plus the distance to the level of the water in the cistern is the total suction lift. If the suction lift exceeds 24 ft., trouble may be expected, principally from air liberation. Long lines like these should be provided with air chambers to take up pulsations and, in the case of the suction, to prevent cavitation.

Velocities like 10.9 f.p.s. and 6.3 f.p.s. for discharge and suction lines respectively are much too high for efficient and continuous operation. High velocity in the discharge pipe results only in increased power consumption; but high velocity in the suction pipe is equivalent to high suction lift with its attendant evils of vaporization and air liberation.

It was stated that by placing the pump near the boilers there would be available steam at 130 lb.—an increase of 50 lb. over the pressure at the present location. The pumping head in the present position is 70 ft.,—presumably the total, or dynamic head. The added friction head for the proposed position would be $60.6 + 16 = 76.6$ ft., or 33.2 p.s.i., making a new total of $76.6 + 75 = 151.6$ ft. or 65.7 lb. The higher steam pressure will add little to the friction loss in the pump, and mainly in the steam valves if they are of the common slide type. Assuming a mechanical efficiency of 75 per cent for the present location, the theoretical m.e.p. in the steam cylinder is $80 \times 0.75 = 60$ p.s.i. gage, or 75 p.s.i. ab., showing that 20 lb. is required to overcome the friction. If a higher steam pressure adds nothing to the friction loss, then to pump the water against the higher head in the proposed position, or 152 ft., the steam pressure would increase as the absolute pressures of the steam and water, or $\frac{(152 + 34)(60 + 15)}{(70 + 34)} = 134$ lb. ab., or 119 lb. gage. Adding the 20 lb. for friction, the steam pressure required for the proposed location of the pump is 139 lb. gage.

Assume that the steam line to the pump is 1½-in., and that it is covered with 1-in. insulation through which there is a heat loss of 0.4 B.t.u. per deg. temp. diff. per sq. ft. per hr. The temperature of saturated steam of 80 lb. gage is 324 deg. F. With a mean yearly outside temperature of 50 deg. F., the average heat loss from the steam pipe would be $0.4\ (324 - 50) = 109.6$ B.t.u. per sq. ft. per hr. The outside area of the insulation is about 1 sq. ft. per lin. ft. of pipe, so the heat loss is $360 \times 109.6 = 38.400$ B.t.u. per hr., or the condensation of $38.400/893.5 = 43$ lb. steam per hr. from 80 lb. gage.

Taking the mechanical efficiency of the pump as 75 per cent, the water horsepower in the present position is $250 \times 8.34 \times 75/33{,}000 \times 0.75 = 6.32$ hp. Assuming a steam consumption of 150 lb. per i.hp., the steam used is $6.32 \times 150 = 947$ lb. per hr. The weight of steam at 130 lb. ga., is 0.3227 lb. per cu. ft., and at 80 lb. ga., is 0.2145 lb. per cu. ft. Grant that the available pressure of 130 lb. is sufficient for the added head. In the proposed position the same volume of steam would be used, but its weight would be $947 \times 0.3227/0.2145 = 1{,}425$ lb., an increase of 478 lb. Obviously it would not pay to move the pump to avoid the loss of 43 lb. of steam by radiation and incur an added steam consumption of 478 lb., because of the added friction head. In the proposed location there would be a small saving of heat that is now radiated from the exhaust line—assuming that the exhaust is returned to the boilers.

One might wonder why a steam pump should be used in such a position at all. It would seem that for this job a power pump would be indicated.

Excerpts from Other Letters

The thing that we liked about all the letters received was the general agreement that it would be decidedly

impractical to move the pump merely to avoid the condensation losses in the 100 ft. of steam line from the factory line to the pump. Nearly every answer was quite emphatic about this.

P. L. Armstrong of Los Angeles was quite sure of this, but he prefaced his letter with the following story which he says a visiting engineer told on himself.

"A member of the Operating Department asked this engineer if a certain pump could be used for a certain service. After figuring three days this engineer called back the operating department and told them that it was impossible. The operating department said: 'The heck it is? We have had the pump connected and are running it.'

"Despite this story," continues Mr. Armstrong, "I am going to say that your pump would not operate if it was moved to the boiler plant."

In the first place you used the word "cistern" which to my mind means a tank which would be below ground level or at least would not be more than 3 or 4 ft. above ground level. On this basis a 4 in. suction line 360 ft. long would be entirely too long.

Quoting the standards of the "Hydraulic Institute" the friction drop of a 4 in. line is 6.72 ft. per hundred or a total of 26.2 foot friction, for the 360 ft. of pipe. By the same authority, only about 20 ft. is the allowable suction lift and this only for a short length of pipe.

Also, if the pump in question was purchased for the purpose it would be a size approximately 10x12x16 Simplex. Even though your steam pressure is 130 lb. at the boiler and only 80 lb. at the present location, this increase in pressure would not compensate for the increased liquid end pressure required.

Now then, if we assume that by some method you are able to get the water to the pump it would not be practical to do so because the increased steam consumption would more than offset the condensation in the 100 feet of steam line.

The increased horsepower would be made up as follows: 360 ft. of 4 in. suction line, approximately 26 ft. friction head, 360 ft. of the 3 in. discharge line approximately 98 ft. or a total of 124 ft.

The hydraulic horsepower or 250 g.p.m. against 124 ft. is approximately 7.8. If we assume 90 lb. steam on a Simplex Pump per hydraulic horsepower or even 100 lb. of steam, this is only 780 lb. of steam per hour. Using the rule of thumb, 1,000 B.t.u. per pound of steam that is 780,000 B.t.u. per hr.

Now this steam line between the main line and the present pump is probably 1½ in. or 2 in. Using a 2 in. line and quoting "Kent", Volume 2, Section 3, Page 68, the radiation loss is 90 B.t.u. per lineal foot per hour or approximately 9,000 B.t.u. per hour per 100 feet. This 9000 B.t.u. is for the least economical pipe covering. It would be decidedly less for a better grade of pipe covering, also the number of B.t.u.'s required to operate the pump if you use a Duplex Pump would be 25 to 30 per cent more than would be required to operate the Simplex Pump the writer selected.

From this you can see it is much more economical to leave the pump in its present location.

If you tell me it isn't—like the engineer above, at least, that is the way I figure it.

This is an excellent letter and we only regret that Mr. Armstrong did not discuss the question of using or not using the exhaust steam, since this would have placed his letter definitely in the prize winning class.

T. Holtz of Pottstown found ample justification for moving the pump on the basis of the possible recovery of exhaust steam, but he neglected to consider the increased friction heads imposed by the long suction and discharge lines. In the absence of any return from the recovery of exhaust steam he advised to do nothing. Quoting from his letter:

"Based on the conditions outlined, and particularly upon the statement that the object of arranging the equipment is to avoid condensation losses in the steam line supplying the pump, the obvious answer to this question, from the economic viewpoint, is to do nothing.

"As in every similar problem, the saving resulting from a given improvement must be balanced against the cost of that improvement.

"The cost of making the change suggested will include excavation and backfilling the trench for burying the pipes below the frost line, the cost of 360 ft. of 3-in. and 4-in. pipe, some additional valves and fittings, and the labor of installing the piping, and moving and resetting the pump, including foundations, steam and exhaust connections, etc.; all of this will vary so widely depending upon local conditions that it is not feasible to give a detailed estimate here. However, it is safe to say that the rearranging of the equipment as outlined will cost a minimum of $800.00.

"To repay this expenditure we should have the saving due to elimination of condensation losses in the steam line to the pump. Assuming this to be a 2-in. line, the hundred feet will have an exposed area of 62 sq. ft., resulting in a condensation of say 50 lb. of steam per hour if bare, with a probable reduction to not over 10 lb. of steam per hour if properly covered with a good insulating pipe covering. If the steam pressure is kept on this line continuously we should have a loss of 87,360 lb. of steam per year, which with moderately efficient boiler room equipment could be produced with 5 tons of coal, costing say $25.00.

"Thus the proposed rearrangement, under the conditions outlined, would make possible a saving of $25.00 per year but require an expenditure of $800.00. Since every assumption made is well on the conservative side, further comment is unnecessary.

"However, if the exhaust available in the boiler room for heating feedwater is not sufficient to heat the feedwater to at least the boiling point, there would be a further saving, through the utilization of the exhaust steam from the pump, that might alter the picture materially.

"To pump 250 g.p.m. against a 70 ft. head requires 4.4 h.p., or at the steam rate of the average direct acting pump, about 500 lbs. steam per hour. If this pump works say half time, 12 hours per day, the exhaust steam available will be $500 \times 12 \times 365 = 2{,}190{,}000$ lbs. per year.

"If this steam can be effectively utilized it will mean a reduction in coal consumption of approximately 135 tons per year, a saving of $675.00 per year. This with the saving in condensation will amply justify the cost of the rearrangement.

"It will be apparent that in considering these possibilities, a number of assumptions have been made that might be found wide of the mark under conditions actually existing. Therefore, 'Our Hero' must base his decision on a careful study of actual conditions."

We regret that lack of space prevents us from publishing more of the replies. Quite a number suggested the use of a diagonal line direct from the boiler plant to the pump. Whether this is possible or not, only our hero can tell, but in any case it would not help matters much, since the cost of such a line would certainly counteract any savings in reducing the radiation losses.

W. Freeman Smith of Danville, Ill., showed an excellent appreciation of all of the elements involved in the problem and his letter was one of the few that suggested the use of a smaller steam line to the pump but carrying a higher steam pressure.

"We would increase the pressure in the steam line to the pump and the factory as well," he writes. An increase in steam pressure would not mean an increase in steam temperature in the same ratio. Therefore, heat losses from a higher pressure and the resulting condensation in the line would not be as great as the pressure increase. Moreover, since heat is lost only at the surface of a pipe, a high pressure steam line of the smallest diameter consistent with the demand is suggested. This small high pressure line could be lagged and the result should be satisfactory." Mr. Freeman also wonders about the relation of the cistern capacity and the water temperature to the problem. As he puts it, "It's a Goshawful big cistern to need a 250 g.p.m. pump to empty it."

Other letters deserving of honorable mention are those of Frank H. Broome, Pompton Lakes, N. J., and Arthur E. May, Kaukauna, Wis.

Taken all in all, our hero should have no further doubts in his mind as to what to do with regard to his pump. He alone knows all the conditions and with these answers which certainly discuss every aspect of the problem he should have no difficulty in working out the most economical and satisfactory solution to his problem.

Questions And Answers

Circulating Pump

Q. WILL you tell me if more air is apt to be entrained in water used for condensing steam in a surface condenser, if the condensing water is pumped through the tubes by a centrifugal pump instead of a plunger type pump? If so, why?
Cleveland, O. A. H. D.

A. INASMUCH as the air dissolved or absorbed in water depends upon the source of the water supply it is independent of the type of pump used, provided of course that the pump suction is properly installed so that air is not sucked in at this point.

Air liberated in the form of bubbles will of course depend upon local conditions and is influenced primarily by reduction in pressure in different parts of the system. Air bubbles once formed do not readily go back into solution and collect on the metal surfaces where the oxygen in the air causes corrosion.

For a more detailed opinion on the effect of the pump the question was submitted to one of the large pump and condenser manufacturers with the following result:

"Having in mind the relative propensity for air liberation, with resulting corrosion at the tube inlets, the answer is affected largely by local conditions. Necessarily there is a churning of the water entering and leaving the cylinder and passing through the valves in a direct-acting pump. This action may be more than in the case of a centrifugal pump if the latter is running at a reasonable speed suitable for the head and capacity requirements. If, however, the water is handled by a centrifugal pump designed for a head considerably higher than that required, or at a speed higher than that required, or both, cavitation may result and air will separate from the water. This will result in noisy operation and possible corrosive action upon the tube inlets.

"It is true that the pulsating action of the direct-acting pump tends to loosen air bubbles from surfaces after they have formed, but, on the other hand, the reciprocation of the piston and the reversing of water flow through the valves has a tendency to foam the water, so that the disadvantages considerably outweigh the possible advantages of pulsation.

"In general we would say that when a pump has been selected carefully to fit the system capacity and head, and is operated at moderate speeds the advantages are definitely on the side of the centrifugal type of pump.

"In any surface condenser installation it is not only important to design the condenser water boxes with liberal area, and with no internal projections or obstructions to cause sudden pressure drop with resulting turbulence and air liberation, but it is also important to give similar careful thought to the design of the entire hydraulic circuit, from the intake tunnel to the discharge. In addition to using a well-designed circulating pump of moderate speed and reputable manufacture, one should allow ample space for piping connections, so that there will be no sharp turns, and so that the velocity through the inlet and discharge piping may be kept within reasonable limits."

C. F. HENDRIE
Steam Power Division
Worthington Pump & Machy. Corp.
Harrison, N. J.

Boiler Failure

Q. WHAT may cause a boiler failure when a steam main breaks?
Detroit, Mich. L. W. H.

A. WHEN a steam main breaks the sudden reduction of pressure may cause priming, which quickly lowers the boiler water to below the danger point and leave dry, portions of the tubes and shells exposed to the heat. Even though the fires be smothered quickly there is sufficient residual heat in the setting to warp and loosen the tubes or flues.

In some cases the danger may be augmented by cold feedwater entering the boiler and causing unequal expansion. The action takes place so suddenly that little can be done. Even when valves are available so that the break can be isolated, they must be closed cautiously to avoid dangerous water hammer and other ruptures.

If the boiler does not prime badly, or can be isolated, so that the water level can be maintained, the feedwater flow should be restricted to the quantity needed to maintain minimum water level. If the water level drops below the danger point, the feedwater should be shut off to avoid the danger of cold water coming in contact with hot surfaces to cause unnecessary temperature strains. In any event the fires should be shut off or smothered as quickly as possible. A boiler subjected to such treatment should be thoroughly inspected before being put back into service.

Motor-Generators and Generators in Parallel

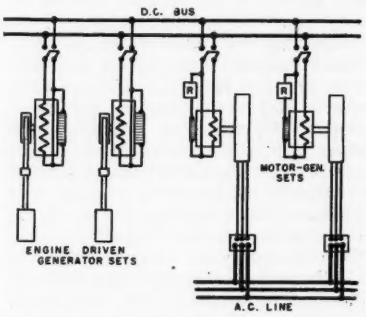
Q. 1. I WOULD like to have some advice on the following problem:

A certain plant has two engine driven 115 v. d.c. generators, one of 250 kw. and the other of 125 kw. capacity.

There are also two motor generator sets, generating current at the same voltage, one of 300 kw. capacity and the other a 100 kw. machine.

The motors on the motor-generator sets are 2300 v., 3 phase synchronous motors. The motor-generator sets often run in parallel with the engine driven generators.

Since the synchronous motors are the same as A.C. generators, if they were to be driven by the D.C. end, would they not generate a.c. power and in this way, in the event of failure



Generators and motor-generators in parallel.

of the outside power supply, be able to furnish a.c. power to other parts of the plant? Most of the power used is direct current; only the current for lighting and process work is a.c.

2. The second question is: if, with the motor generators in parallel with the engine driven generators, the a.c. power from the outside is cut off, would the d.c. generators driven by the synchronous motors continue to run as motors and drive the synchronous motors as generators?

3. A third question is:

Supposing that the outside power was not available on starting the plant in the morning, what apparatus would be required to start the motor generator sets using the d.c. end and power developed by the engines?

GEORGE H. KIMBALL.
Cambridge, Mass.

A. 1. Yes. In case of failure of the outside source of a.c. power, the motors, of course, would instantly tend to slow down, but in doing so the d.c. generators which they drive would also tend to slow down, causing them to take power from the d.c. mains and become motors. In that capacity they would continue to drive the synchron-

ous motors and they would then deliver a.c. power to the a.c. equipment within the plant. Of course, in this reversal of function the excitation on both the d.c. generators and the synchronous motors would have to be readjusted.

2. Question No. 2 is really the same as No. 1 and has already been answered in the foregoing paragraph. The answer is yes, the d.c. machines would continue to run as motors and drive the synchronous machines as generators.

3. The only apparatus needed to start the motor generators from the d.c. end is a rheostat by means of which the armature current can be limited to a low value at the beginning of the starting operation. A direct current machine of any capacity offers a very low resistance to the flow of electricity when the armature is at rest because of the absence of the counter-e.m.f. At rest, the current through the armature is limited only by the resistance of the winding and this is usually very low. Hence it becomes necessary to introduce external resistance into the armature circuit during the starting period, at least until the counter e.m.f. begins to build up. Since the counter e.m.f. opposes the applied e.m.f., as the machine speeds up the external resistance can gradually be cut out, and when full speed is attained, the armature can be connected directly across the supply mains. The rheostats should be connected only in the armature circuits as shown in the accompanying diagram of the system.

What Causes Engine Knock?

Q. For some undetermined reason I am having trouble with one of my engines, a four valve Russell with the governor in the flywheel. This engine will run smoothly for a while, sometimes for a week or two, and suddenly begin to knock, apparently on the side of the cylinder. I have tried changing the cutoff without success and if you have something else to offer I will be very grateful. F. L. J.

A. In a general way any four valve engine is prone to become noisy at times. When the engine is first started up and before the load is put on, the cutoff is so early that the expansion line drops below the atmospheric line. At this time the partial vacuum in the cylinder will lift the exhaust valves from the seat the moment release takes place.

The writer has seen engines of this type and also engines of the Corliss type when running under an intermittent load, click (or knock, if a large unit), whenever the loads fall off momentarily.

Cross compound Corliss engines which have large cylinder ratios, and intended to operate at 80 per cent load or better, will also have that "lifting click" in the l.p. exhaust valves if the load drops considerably.

WE DON'T KNOW EVERYTHING

Much as we dislike to admit this, nevertheless it's true: and the older we get the more true we find it. Of course, as a rule, we put up a bold front and when people talk to us in terms of things they assume we know all about but as a matter of fact of which we understand very little, we look wise and say as little as possible. And this usually works; our silence is regarded as erudition. However, there are times when direct questions put us on the spot and then we usually are forced to admit that we don't know and try to find somebody that does know the answer. As an example, we cite the questions on these pages about the manufacture of dry ice by C. H. T. He wants to know all about making it—expense, equipment, operation, etc. Well, about all we know about dry ice is that it's very cold, looks like snow and that the ice cream that comes in it has the general characteristics of a high temperature furnace refractory. So we are passing the buck to you. Perhaps there are some kind souls among you readers who have had experience in the manufacture of dry ice and who will give C. H. T. some information.

It would be a good idea to look into the governor of the engine as a matter of principle. There is an old saying that "anything can happen to a governor and generally does." In some types the "knife edge pins" which sustain spring ends, etc., have a nasty habit of either wearing down blunt, or wearing into the spring end. In either case friction is set up and affects speed regulation.

While on the whole, roller bearings instead of knife edges give a better arrangement, there is still a possibility of trouble. All too frequently engineers use any old grease in their governor ball bearing races (sometimes because the boss will not buy good grease, viz. vaseline), and while it may, and does, function well for several years, sooner or later the resinous content will separate from the lubricant content (through centrifugal force) and gradually build up a substance which will be found to be pure rosin.

Under these conditions fulcrum pins wear abnormally and the speed will vary up to ten per cent. The writer traveled over a thousand miles to repair two governors which were so completely "frozen" with resin that new fulcrum pins and ball races were necessary.

Incidentally, even when commercial "brick vaseline" is used, once in a very long while the ball races will be found not hardened properly, if at all, and the balls will imbed themselves in the race to the detriment of regulation. The writer has found but one instance of this kind in many years on the road and was surprised to find on the defective roller bearings the well known name of a successful manufacturer. The above instance was just one of those things "that happen" to prove that "anything can happen to a governor and generally does."

It is not easy to fix something unless one sees it. For instance, my last job was an experience with a soft ball race. I drove out from our shop and saw the engine running.

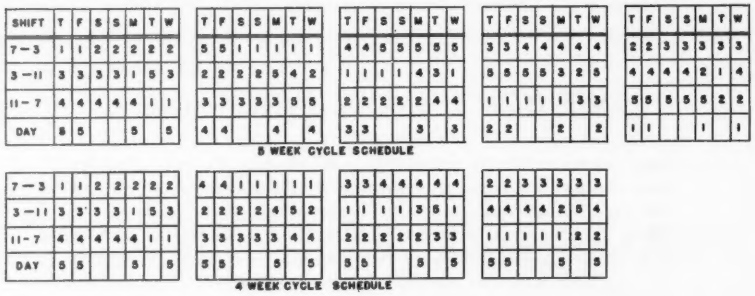
"Vos is lose, Oscar?" and Oscar opined that the "ramrod" in the governor was worn which made it hard to operate the synchronizing device. (See Nordberg's Uniflow catalog.) I didn't think so, for there were some peculiarities which disproved it, or rather which did not prove it, which is splitting hairs.

We shut down and loosened up the governor springs enough to take out the ramrod. In loosening the springs I noticed one of the pendulums (weight arms) move sideways, which is not according to Hoyle or Hitler. I showed Oscar the ramrod and it was as good as the day it left our shop in 1916. Then I told him to "yiggle" the weight arm and he did. Here was the trouble.

But the remarkable thing about it was that they were using hard brick vaseline on the engine since it was installed and there was no sign of resin of any kind. The fulcrum pins were worn some by reason of the fact that where the balls imbedded themselves into the soft ball races the combination moved the inner race cornerways which wore the fulcrum pins enough to spoil them.

The ball races were spotted as to hardness and in most places could be touched with a file like Swedish Iron. I made new fulcrum pins and put in all new ball bearings made by the same manufacturer as the first, and cut her in on the board. Was lucky! did not have to put a wrench on anything to adjust her, and she synchronized at exactly the same notch as when first set up. George H. Wallace

Waukesha, Wis.



SHIFT	T	F	S	S	M	T	W
7—3	1	1	2	2	2	2	2
3—11	3	3	3	3	1	5	3
11—7	4	4	4	4	4	1	1
DAY	5	5			5		5

T	F	S	S	M	T	W
5	5	1	1	1	1	1
2	2	2	2	5	4	2
3	3	3	3	3	5	5
4	4			4		4

T	F	S	S	M	T	W
4	4	5	5	5	5	5
1	1	1	1	4	3	1
2	2	2	2	2	4	4
3	3			3		3

T	F	S	S	M	T	W
3	3	4	4	4	4	4
5	5	5	5	3	2	5
1	1	1	1	1	3	3
2	2			2		2

T	F	S	S	M	T	W
2	2	3	3	3	3	3
4	4	4	4	2	1	4
5	5	5	5	5	2	2
1	1			1		1

5 WEEK CYCLE SCHEDULE

7—3	1	1	2	2	2	2	2
3—11	3	3	3	3	1	5	3
11—7	4	4	4	4	4	1	1
DAY	5	5			5		5

4	4	1	1	1	1	1
2	2	2	2	4	5	2
3	3	3	3	3	4	4
5	5			5		5

3	3	4	4	4	4	4
1	1	1	1	3	5	1
2	2	2	2	2	3	3
5	5			5		5

2	2	3	3	3	3	3
4	4	4	4	2	5	4
1	1	1	1	1	2	2
5	5			5		5

4 WEEK CYCLE SCHEDULE

Work Schedule for J. M.

THE DILEMMA of J. M. of Newark, N. J., as outlined by him in the August issue (page 542) is quite understandable to us as we have spent many hours and suffered several headaches before we finally arrived at a 5 day, 40 hr. schedule which would meet with 100 per cent approval of the men concerned.

The resulting schedule which I give herewith gives each engineer 72 hr. off (3:00 p. m. Friday to 3:00 p. m. Monday) once in every four weeks and 48 hr. off during each of the three remaining weeks of the 4 week cycle. It will be noted that this schedule gives each engineer absolute equality as to working Sundays and first, second or third tricks. This is a matter which some men grow quite jealous over, particularly if time and one-half or double time rates are paid for Sunday service.

Since J. M. has 5 engineers it would appear advantageous to use all 5 men on a swing shift schedule which would give each man a turn as maintenance man. This would also have the further advantage of affording each man an additional long week end of 48 hr. (Saturday and Sunday) off once in the 5 wk. If the maintenance shift is to be awarded on a basis of seniority, or as a concession to some preferred employee who objects to turn shift duty consideration of this 5 wk. cycle will be unnecessary, but barring any such deciding factor, the 5 wk. cycle would appeal to me because it treats all men with equality and gives a 72 hr. and 48 hr. week end off in each cycle.

J. M. will please note that the schedules have been deliberately set up to throw the 72 hr. and 48 hr. "off" periods on the week ends as most men would prefer, and although this system may not tie in with his employer's pay week, this will have no effect on the paymaster's problems or the men's pay envelopes, once the system gets under way. In both schedules men are identified by numerals which can be replaced by the men's initials if either is adopted. No. 5 is, of course, the maintenance man throughout the 4-week cycle schedule.

Our men experienced a little confusion when this schedule was first inaugurated, but today their enthusiasm for it is high.

Chillicothe, O. JOHN B. MILLER

Calculating Pump Dimensions

Q. 1. A COLD storage plant requires the circulation of 500 g.p.m. of brine at a pressure of 15 lb. per sq. in. If the piston speed is 50 ft. per min., the ratio of piston diameter to stroke is 1.33 to 1, and an allowance of 15 per cent is made for slip, what must be the dimensions of the pump cylinders for the plant?

Q. 2. In the above question, if the steam pressure is 80 lb. ga., following full stroke, and an allowance of 10 per cent is made for frictional resistances, what must be the diameter of the steam cylinders?

Baltimore, Md. C. W. P.

A. Inasmuch as a slip of 15 per cent has been assumed the pump displacement must be $(500 \div 85) \times 100$ or 588 g.p.m. There are 7.5 gal. in a cubic foot and 1728 cu. in. in a cubic foot, so 588 g.p.m. represents a displacement of $588 \div 7.5$ or 78.5 cu. ft., or $78.5 \times 1728 = 135{,}500$ cu. in. per min. The displacement of a pump per minute is the area of the piston times the length of stroke times the number of strokes per minute times the revolutions per minute, or

$$D = 0.785\ d^2 \times L \times S \times N \quad (1)$$

Where D = piston displacement in cu. in. per min.
d = the diameter of piston in inches
L = the stroke in inches
S = number of strokes per revolution—two in the case of a simplex and 4 in the case of a duplex pump
N = revolutions per minute

If the ratio of diameter to stroke is 1.33 to 1, then $d = 1.33\ L \quad (2)$

Again if the average piston speed is 50 ft. or $50 \times 12 = 600$ in. per minute and each piston must make two strokes per revolution, the speed N is

$$600 \div 2\ L \text{ or } 300 \div L \text{ r.p.m.} \quad (3)$$

Substituting Eq. 2 and 3 in Eq. 1, we have for piston displacement per minute—

$$D = 0.785\ (1.33\ L)^2 \times L \times S \times (300/L) = 418\ L^2\ S$$

If we assume a simplex pump where $S = 2$, then

$$135{,}500 = 418 \times L^2 \times 2$$

or $L = 12.7$ and $d = 1.33 \times 12.7 = 16.9$ in.

With a duplex pump $S = 4$ and $L = 9$ and $d = 12$, which is a more reasonable size and probably the type referred to in the question.

2. The thrust of the brine on the piston is the pressure of 15 lb. per sq. in. times the area of the piston, or

$$15\ (0.785 \times 12^2) = 1696 \text{ lb.}$$

Making an allowance of 10 per cent for friction, which is another way of saying the mechanical efficiency is 90 per cent, the steam force must be equal to $1696 \div 0.90 = 1885$ lb.

Taking the steam pressure at the end of the stroke as 80 lb., the area of the steam piston must be such that its area times 80 is equal to 1885, or

$$0.785\ d^2 \times 80 = 1885$$

$$d = 5.5$$

The required pump would therefore be a 12 by 9 by 5½ in. horizontal duplex, although a 6 in. steam cylinder would probably be used for commercial reasons if a standard pump was not sized close enough for the purpose. This assumed piston speed of 50 ft. per min. for a 9 in. stroke and low head service agrees very closely with the speed chart on page 463 of the July 1939 issue.

Where Should the Idler Pulley Be Located?

I WOULD like to have the opinion of other readers in regard to the location of idler pulleys on belt drives. In my care, I have a horizontal drive, 20 ft. between shaft centers, pulleys of same diameter, slack side on top. Should the idler be near the driver or driver pulley?

My experience is that wrapping the driven pulley to prevent slippage gives but very little advantage. With the idler near the driven pulley, as the load comes on, the belt stretches and is slack just as it leaves the driver. If this slack is taken up at the driver there is very little danger of slippage on the driver, even to the load limit of the belt. It is my contention that with the idler near the driver vibrations in the slack side of the running belt are immediately ironed out and a much smoother running belt drive is obtained.

Lisbon, N. H. C. L. W.

Wanted, a CO_2 Bonus System

I WOULD like to put into practice a system by which the firemen in our plant would be paid a bonus, over their regular wages, based on the CO_2 they maintain on their shifts. Can anybody who may have had experience with such systems advise me as to how the plan is worked out. Any advice will be gratefully appreciated.

New Hope, Pa. C. B. O.

Boiler Horsepower

Q. 1. How many pounds of water will a 250 hp. plant use in 24 hr. at normal rating?

Q. 2. How much excess capacity should a feed pump have when installed for a given boiler? L. W. D.

A. 1. There is not sufficient data given to answer the first question accurately. To do this it is necessary to assume the feedwater temperature and the steam pressure and temperature.

Boiler horsepower, now becoming obsolete, has had a long and interesting history. The old Centennial Rating was based on generating an indicated horsepower hour on 30 lb. per hr. of 70 lb. saturated steam. The corresponding boiler horsepower assumed with 100 deg. F. feedwater. Later it was arbitrarily assumed that 10 sq. ft. of boiler heating surface was a reasonable surface to accomplish this.

As steam pressures increased the Centennial Rating proved to be inadequate and the boiler horsepower was revised on the basis of evaporation "f and a 212 deg. F.", that is from water at 212 deg. F. to steam at 212 deg. F., representing a latent heat input of 970.4 per lb. The heat input to 30 lb. or 70 lb. steam with 100 deg. F. feedwater was later taken as equivalent to 34.5 lb. of steam "f and a" or $34.5 \times 970.4 =$ 33,479 B.t.u. per hr.

To determine the actual evaporation as contrasted to evaporation "from and at" it is necessary to consider the factor of evaporation. Thus with 100 lb. ga. saturated steam the total heat content above 32 deg. F. is 1189 B.t.u. per lb. With 212 deg. F. feedwater $212 - 32$ or 180 B.t.u. is supplied by the feedwater, leaving only $1189 - 180 = 1009$ B.t.u. to be supplied by the boiler. The factor of evaporation is, therefore, 1009/970.4 or 1.11. That is, the actual evaporation for each boiler horsepower would be 34.5 divided by 1.11 or 31.1 lb. The factor of evaporation is increased by an increase in pressure and by superheat and is decreased by an increase in feedwater temperature.

Thus in the above question, assuming 100 lb. ga. saturated steam and 212 deg. F. feedwater, the water required at normal or 100 per cent rating would be 250 times 31.1 or 7775 lb. per hour, or 186,600 lb. in 24 hr.

2. There is no established excess or over capacity ratio for boiler feed pumps, but it was customary in the days of low pressure boilers and direct acting pumps to figure the boiler feed pump capacity on the basis of 45 lb. of water per boiler horsepower, that is from about 30 to 50 per cent over capacity. The pump capacity is of course directly proportional to pump speed and boiler feed pumps are generally rated at a speed of about two thirds of the same size pump used for general service.

Scale Removal

Q. CAN you tell me if it is practical to remove about 3/10 in. of scale from an h.r.t. boiler? If so, how do you go about it? D. K.

A. SCALE can be removed from boilers and heat exchangers by acid or chemicals but it is desirable to have the methods in a particular case outlined by a chemist in order to get the correct acid concentration. The use of acid always involves possible danger to both workmen and equipment and must be carefully supervised.

Details of the procedure followed by a large utility company in connection with locomotive crane boilers are given on page 407 of the September, 1934, issue. They used muriatic acid, a commercial grade of hydrochloric acid in a water solution containing 10 per cent of acid by weight. An inhibitor to reduce the action of the acid on the base metal was also used in an amount equal to 1 per cent of the weight of acid.

The solution was made inside the boiler by adding water and then acid in small quantities so as to avoid high local concentration. After the boiler was filled with the solution a wood fire was built and the temperature held around 160 deg. F. for a period of 4 hr. with the boiler fully vented to the atmosphere.

At the end of 4 hr. the acid solution was drained out and discarded and the boiler thoroughly washed. The boiler was then filled with water to which 10 lb. of soda ash had been added. This was to neutralize the remaining traces of acid. This solution was boiled for ½ hr. and drained and discarded.

Corrosion Protection of Heaters

Q. CAN YOU TELL me if there is a paint or other material on the market which may be used for protecting the inside surface of new domestic hot water heaters against corrosion? Some of the water is used for cooking and drinking purposes, so that the material would have to be non-poisonous. O. T.

A. BECAUSE of the specialized nature of this question, it was referred to a paint manufacturer and was answered as follows:

Continuous contact with hot water on the inside of a steel tank presents a difficult problem and the severe conditions existing make it absolutely necessary that the proper paint be used and that it be properly applied. The treatment we recommend is one coat of our Sarva Acid-Resisting Paint followed by one or preferably two coats of our Sarva Compound.

In painting the surface there are several precautions that must be observed. The surface must be absolutely clean and dry and ample drying time should be permitted between coats. All dirt, grease, mill scale, rust and loose old paint should be completely removed by wire brushing, sand blasting or other effective methods. When this has been accomplished a coat of the Acid-Resisting Paint should be applied as it comes from the container after having been thoroughly stirred.

This coat should be permitted to dry at least 72 hr. before the succeeding coat of the Compound is applied. If two coats of Compound are used, 72 hr. drying time should be permitted between coats and at least that long before water is turned into the tank.

Both paint and compound are made with special acid-resistant resins and oils. They are exceptionally high in moisture resistance and give protection under extreme acid, alkali or fume conditions. In that they contain no lead they are absolutely non-toxic and can be safely used for the interior of water tanks that are used to store water for human use or consumption. J. H. FINLEY.

American Asphalt Paint Co.
Chicago, Ill.

Who Knows About Making Dry Ice?

THE corporation I am employed by is going into the manufacture of dry ice and liquid CO_2. I would like some information on this subject, particularly as to the cost of installation, equipment needed and operation. About how much CO_2 can be produced, our production being about 7500 gal. of liquid per 24 hr. day. We have four fermenting tanks, capacity 41,000 gal. each. One has to be changed each day to insure continuance of CO_2 gas. If possible I would like a book or data that would tell me about how much CO_2 I can expect each 24 hr. in the solid form. We have our own power plant.

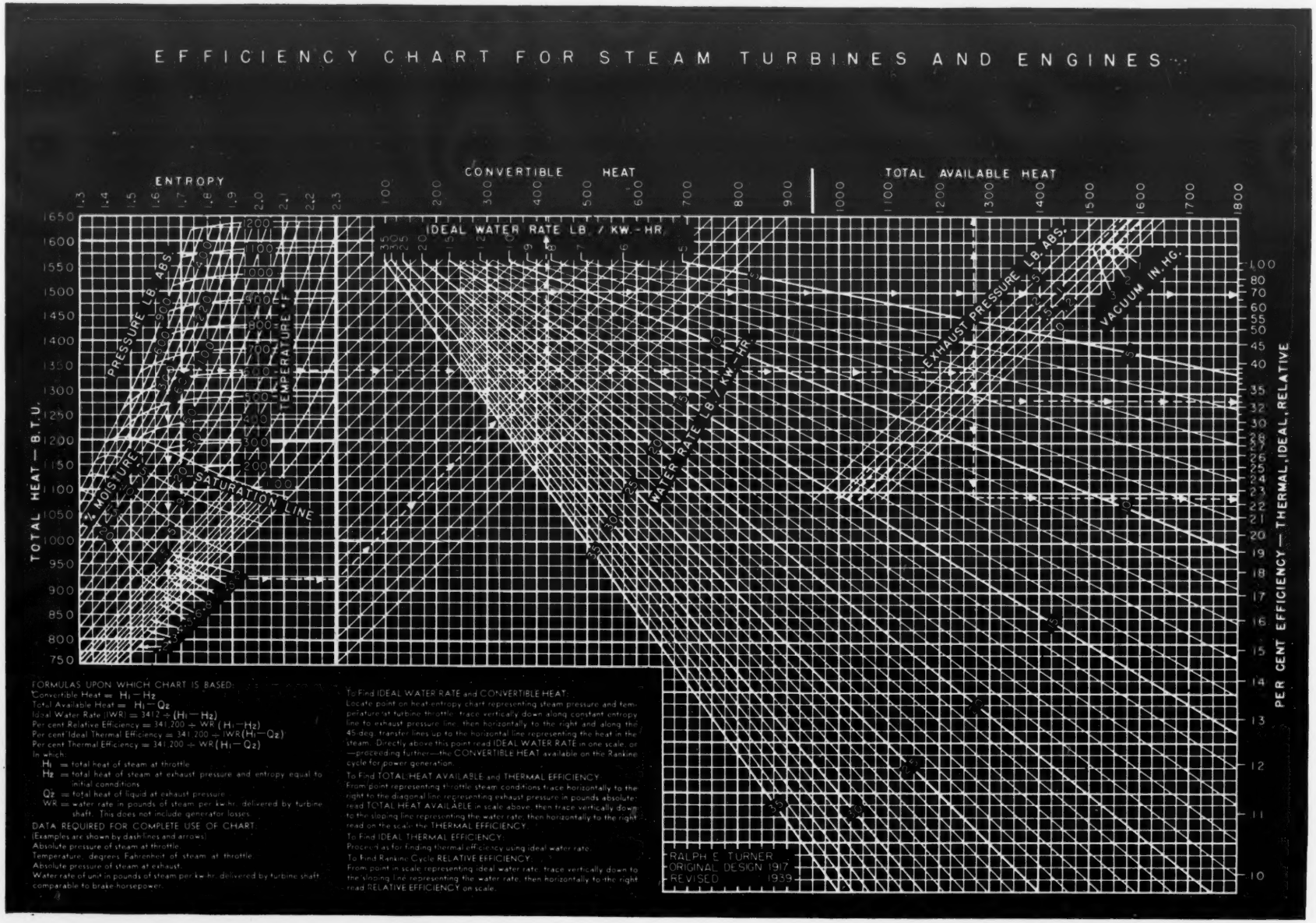
Rochester, N. Y. C. H. T.

Cleaning Ammonia Condenser

IN THE September issue, I see where T. E. Hanson of Chicago is having trouble with scale forming in the condenser pipes of his ammonia system. As the result of my own experiences with scaled condenser tubes I can tell him how to get it out in a hurry. I have tried oil and kerosene and about everything else to remove scale in water pipes, but the only thing I have found that would do the trick effectively is muriatic acid, the stronger the solution, the better. I would not dilute it more than 1 to 5 parts of water. He can take a barrel and put enough water in it to fill his pipes and then add the acid. Use a hand pump to fill the pipes with the solution and let it remain in the pipes for 10 or 12 hr. Unless the tubes are scaled too badly they should be clean by that time; if not, add more acid and let the solution act a while longer. This will not damage the gaskets. When clean, the pipes should be drained and filled up again with water in which baking soda has been dissolved—about 5 lb. per bbl. of water. This will neutralize the acid and prevent further action on the pipes.

Culver, Oregon. C. C. Collins.

Editor's note: When muriatic acid is used to remove scale in this way it is advisable to add an inhibitor to the solution to reduce the action of the acid on the iron. The two most generally used inhibitors are "Rodine," made by the American Chemical Paint Co., Ambler, Pa., and "Incontrol," made by the Inter-Coastal-Paint Corp., E. St. Louis, Ill.



FORMULAS UPON WHICH CHART IS BASED:

Convertible Heat = $H_1 - H_2$

Total Available Heat = $H_1 - Q_2$

Ideal Water Rate (IWR) = $3412 \div (H_1 - H_2)$

Per cent Relative Efficiency = $341.200 \div WR\,(H_1 - H_2)$

Per cent Ideal Thermal Efficiency = $341.200 \div IWR(H_1 - Q_2)$

Per cent Thermal Efficiency = $341.200 \div WR\,(H_1 - Q_2)$

In which:

H_1 = total heat of steam at throttle

H_2 = total heat of steam at exhaust pressure and entropy equal to initial conditions

Q_2 = total heat of liquid at exhaust pressure

WR = water rate in pounds of steam per kw-hr. delivered by turbine shaft. This does not include generator losses

DATA REQUIRED FOR COMPLETE USE OF CHART

(Examples are shown by dashlines and arrows)

Absolute pressure of steam at throttle

Temperature, degrees Fahrenheit, of steam at throttle

Absolute pressure of steam at exhaust

Water rate of unit in pounds of steam per kw-hr. delivered by turbine shaft comparable to brake-horsepower.

To Find IDEAL WATER RATE and CONVERTIBLE HEAT:

Locate point on heat-entropy chart representing steam pressure and temperature at turbine throttle; trace vertically down along constant entropy line to exhaust pressure line; then horizontally to the right and along the 45-deg. transfer lines up to the horizontal line representing the heat in the steam. Directly above this point read IDEAL WATER RATE in one scale, or —proceeding further— the CONVERTIBLE HEAT available on the Rankine cycle for power generation.

To Find TOTAL HEAT AVAILABLE and THERMAL EFFICIENCY:

From point representing throttle steam conditions trace horizontally to the right to the diagonal line representing exhaust pressure in pounds absolute; read TOTAL HEAT AVAILABLE in scale above, then trace vertically down to the sloping line representing the water rate, then horizontally to the right read on the scale the THERMAL EFFICIENCY.

To Find IDEAL THERMAL EFFICIENCY:

Proceed as for finding thermal efficiency using ideal water rate.

To Find Rankine Cycle RELATIVE EFFICIENCY:

From point in scale representing ideal water rate, trace vertically down to the sloping line representing the water rate; then horizontally to the right read RELATIVE EFFICIENCY on scale.

Radio Equipment For Power Companies

COINCIDENT with the quickened interest of power companies in short-wave radio telephone communication as a means of facilitating the dispatching of maintenance crews and similar functions, comes the announcement by Western Electric Company of a new radio equipment designed specifically for this type of service.

Technical experts of power companies who witnessed trials of the system in New York, Kansas City and other metropolitan centers have commended engineers of Bell Telephone Laboratories on the excellence of the communication. Although these tests were conducted under the most unfavorable conditions likely to be encountered in actual practice, the voice came through clearly and with good volume.

Two unique features account for the new instrument's performance. First, its output has been stepped up to fifteen watts—three times as much power as commonly used. Yet almost no increased demand is made on the service car's storage battery. This high efficiency is made possible by the introduction of several recently developed circuits including a coupling arrangement which transfers almost 100 per cent of the energy from the high frequency vacuum tubes to the antenna.

The second and equally important improvement, in effect, peels the envelope of noise from around all incoming speech. Three elements in the receiving set combine to achieve this automatically. The first is an electrical network or equalizer which blocks out most electrical interference. Secondly, an improved automatic volume control maintains the speech at a constant level. The most interesting innovation, however, is a new type of vacuum tube relay used in the "codan" circuit.

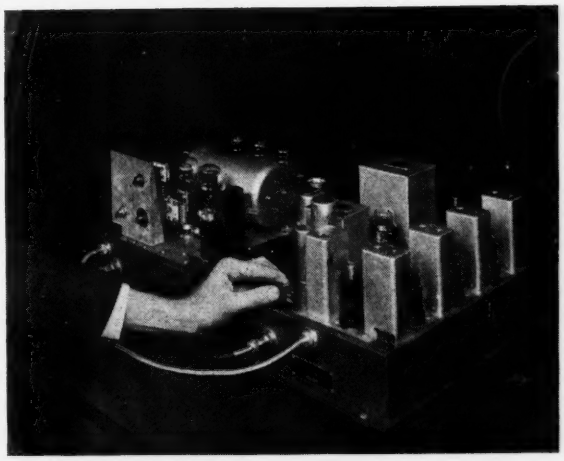


Fig. 1. Both transmitter and receiver for power line maintenance car may be tuned by means of an ordinary screw driver. All working parts are fully exposed and all tuning controls centered on one convenient panel on the front of the instrument

Carrier waves from the distant station actuate this device. In the absence of a signal, the codan shuts off the output of the receiving set. As a result, almost no sound comes through the handset receiver or loudspeaker except during periods of transmission. Unwanted sounds, such as ignition noise created by passing motor cars, or similar forms of electrical disturbance, produce negligible action in the codan.

The transmitter and receiver are built in the form of two compact units which slide into slotted mounting plates attached to the floor of the car's luggage compartment. This method of installation permits either unit to be interchanged easily between various cars of a fleet or to be quickly removed to the maintenance shop for inspection. A complete installation, including tune-up, mounting of the telephone handset, monitoring loudspeaker, and miniature "on-off" switching panel, can be completed in a matter of minutes instead of hours. By lifting the covers which house the units all major parts are fully exposed.

Fig. 2. Arnold Bailey of Bell Telephone Laboratories, communicates with his office as he drives through the congestion of downtown New York. The circular loudspeaker above the starting pedal signals the driver when the car is called from a remote point

Fig. 3. Roger Carlton and William Gaughey of Bell Telephone Laboratories make final tuning adjustments to the transmitter for use in service cars of power companies that patrol power lines. The equipment can be installed in any car in a few minutes

Glass Brick Boiler

At Charlestown, Mass., where H. P. Hood & Sons operates one of the largest milk plants in this country, this company has recently built a new boiler plant using glass brick walls. It is a model of cleanliness and light and it is well in keeping with the modern features of the dairy plant.

Fig. 1. (Left) A view of the exterior of the new Hood boiler plant at Charlestown. Note cooling tower on roof

Fig. 2. (Right) An interior view of the boiler room showing its spacious and orderly arrangement and its cleanliness

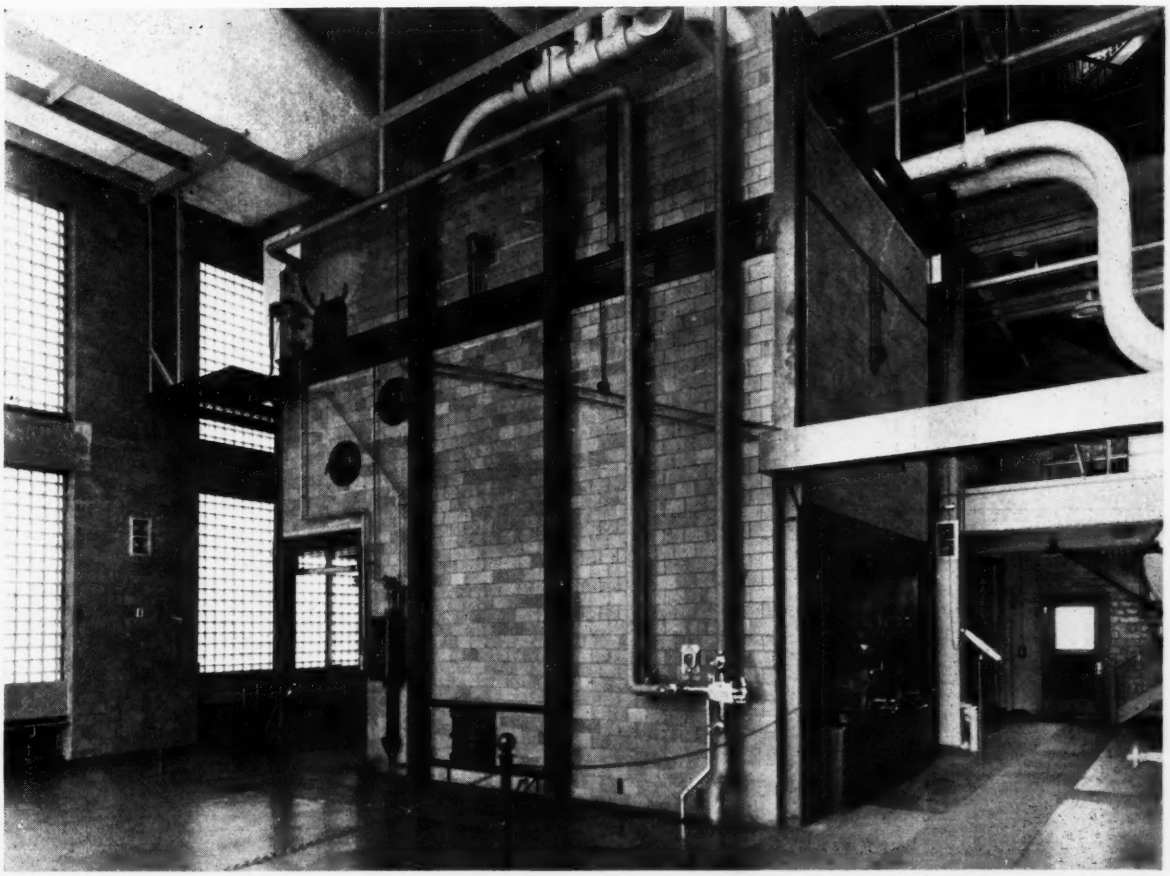
H. P. HOOD AND SONS is almost as much an institution in New England as is Bunker Hill or the Old North Church. For many years this company has dispensed dairy products in the New England States until the name has become almost a byword. With a score of plants and fleets of trucks the company has built up an enviable reputation for prompt service and quality products.

One of the largest of the Hood plants is located in Charlestown, not far from Sullivan Square and quite close to Bunker Hill; this plant in fact is, perhaps, the largest milk plant under one roof in the United States. In line with the company's progressive policy this plant is equipped with the most modern type of machinery, and within the past 18 months a new boiler plant has been built which can well qualify as the finest of its kind; it is as clean and light and airy as any part of the dairy plant.

Views of this boiler plant are shown in the accompanying illustrations. As will be noted the building is of brick and glass construction, smooth, simple and very modern. There are but few windows of the conventional type but since three of the walls are practically of all glass brick construction, the building is flooded with daylight. The entire absence of sash makes it easy to keep the plant clean and reduce maintenance to a minimum.

This boiler plant supplies all the process and heating steam required by the dairy plant and also to a small Corliss engine generating set which is used to supply lighting current. Electric power for other purposes is purchased from the local utility company. About 300 tons of refrigerating capacity is installed but this is all motor driven. Circulating water for this refrigerating equipment is cooled by a Marley cooling tower installed on the roof of the boiler house. The plant was laid out and built by the Hood Engineering Department. Edward M. Laskey, Plant Engineer in charge of Mechanical Work and Construction, had direct supervision of the construction work and installation of all machinery and equipment. The structural design was made by Ganteaume and McMullen, Engineers of Boston, and the plant is now operated by Chief Engineer, Arthur G. Weldon.

Plant at H. P. Hood & Sons



The general arrangement and design of this boiler plant is so simple that it requires little comment—the pictures speak for themselvs. At the present time only one boiler is installed but provision has been made for the future installation of another unit should that become desirable.

Oil is used as fuel, fired by 3 burners installed in the front wall of the furnace. Combustion is controlled automatically by the Askania system of control.

The boiler itself is a B. & W., Stirling Type H unit with 4150 sq. ft. of heating surface and designed for operation at a pressure of 160 lb. per sq. in. The furnace construction is of interest in that it is lined with 100 per cent plastic refractory. The plastic is "Ramtite" manufactured by the Ramtite Co. and it was installed by the Eastern Refractories Co. of Boston. The details of the furnace construction are shown in Figs. 6 and 7. The floor of the furnace is underlaid with hollow tile through which air for combustion is drawn.

Neither forced nor induced draft fans are provided since adequate natural draft is produced by the 185 ft. radial brick stack at the side of the boiler house.

The oil burning system is that of E. L. Wooley Co. of Providence, R. I. The oil is heated in two stages, by two separate heaters. One heater operates at about 3 lb. steam pressure (exhaust from the engine) and the other at from 15 to 17 lb. steam pressure, obtained from the main steam line through a reducing valve. The path of the oil is first through the low pressure heater and then through the high pressure heater.

A 15,000 gal. tank is provided for the storage of fuel oil, located so that it can be filled from railroad tank car or truck. Since only one boiler is available provision has been made to insure a means of maintaining combustion under conditions where the steam pressure dropped to such an extent that the steam driven oil pump failed to operate. This emergency system involves a small motor-driven oil pump, pumping very light oil from a 500 gal. tank. One of the burners is equipped to burn this oil, which requires no heating.

Feedwater is city water, heated by a 54,000 lb. per hr. vertical, cast iron, open Elliott Co. heater, fitted

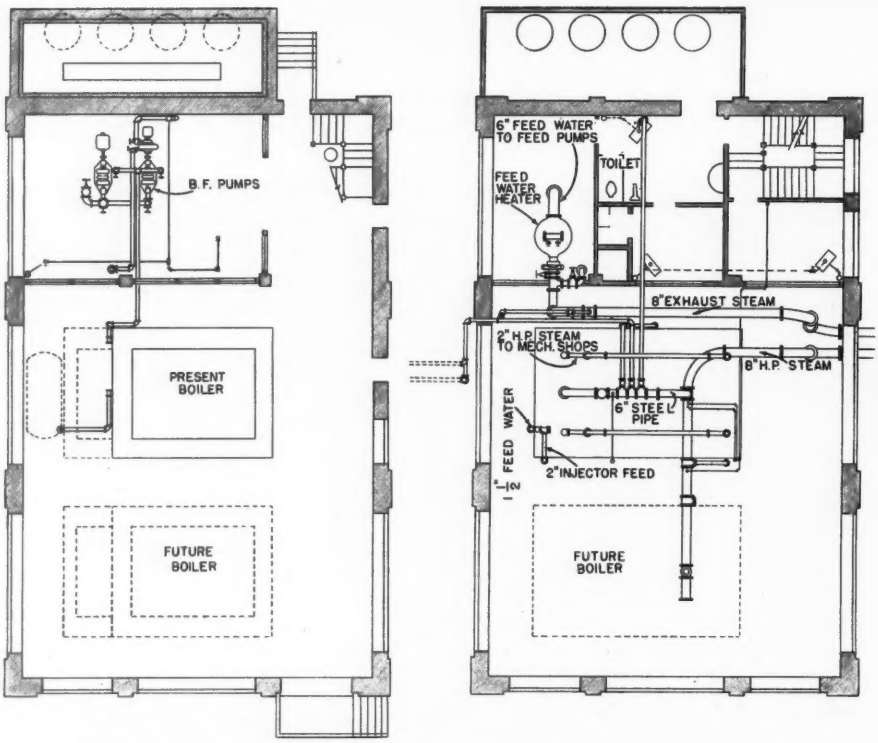


Fig. 3. (Left) Plans of the boiler house at two levels, the first on the operating floor and the second on the feed water heater level. At present only one boiler is installed but space has been left for a future unit

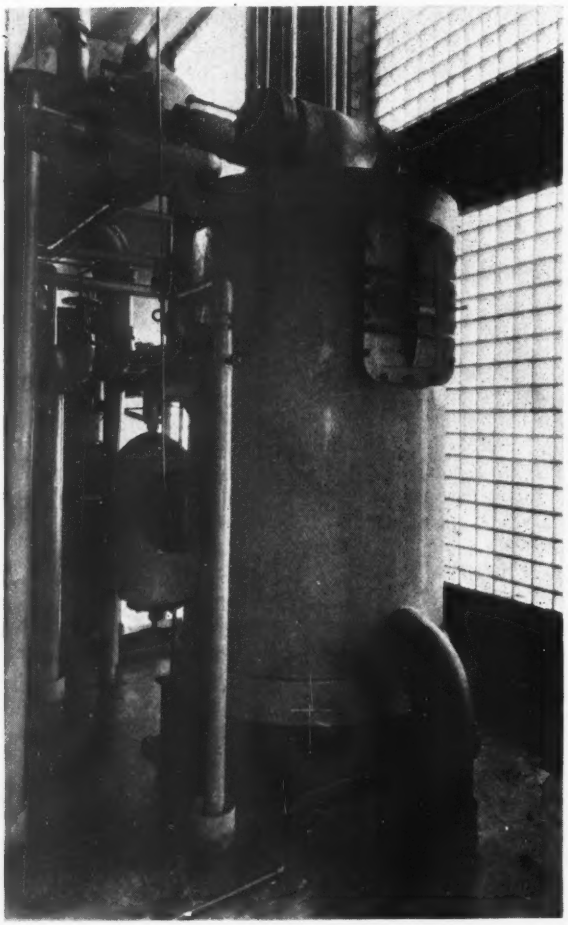


Fig. 4. (Left) The 54,000 lb. per hr. vertical cast iron open heater is fitted with a vent condenser to conserve the heat in the vented steam

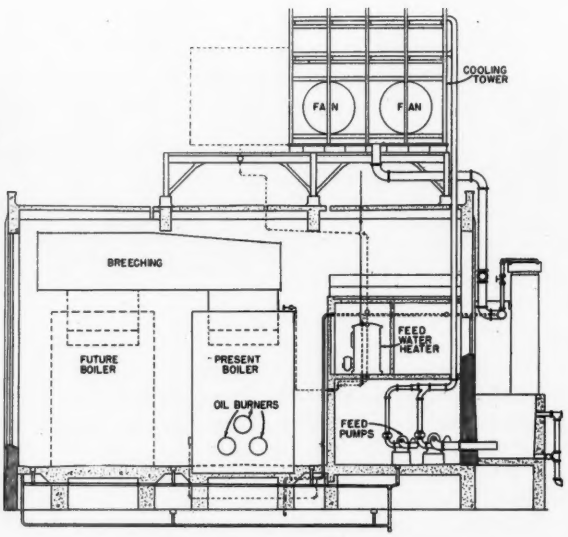


Fig. 5. (Above) Elevation showing the arrangement of the boilers and feedwater equipment and the cooling tower for the refrigerating equipment on the roof

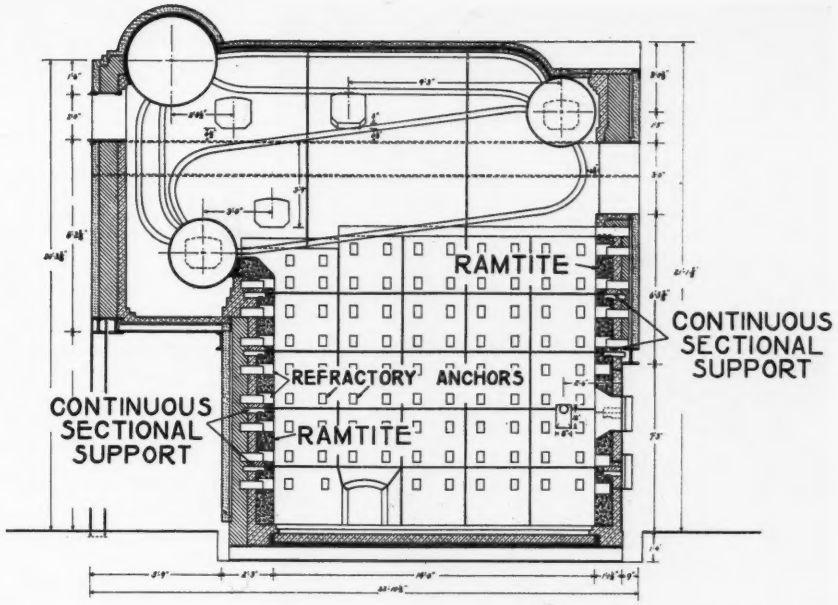


Fig. 6. Section through the boiler showing the details of furnace construction. The furnace is lined with 100 per cent plastic refractory. The floor is underlaid with hollow tile through which air for combustion is drawn

with a vent condenser for conserving the heat in a large amount of venting steam. Two boiler feed pumps are provided, both centrifugal units rated at 180 g.p.m. under 370 ft. head. One of these pumps is driven by a 30 hp. G.E. induction motor, the other by a 30 hp. G.E. turbine. The boiler water system is simple, only the addition of trisodium phosphate being required. This chemical is fed into the main feed line by means of a "home-made" chemical feeder.

The arrangement of the plant requires little comment. As shown by the sectional elevations herewith the main operating floor is practically at grade level, there being no basement. The feed pump and the cooling tower circulating pumps are installed on the

Principal Equipment Installed in the Boiler Plant of H. P. Hood & Sons

General

Location. Charlestown, Mass.
Owner. H. P. Hood & Sons.
Type of Plant. Dairy Products.

Boiler Equipment

Boiler. 1—4150 sq. ft. Stirling, Type H, designed for 160 lb. steam pressure. 340—3¼ in. tubes; 2 steam drums 36 and 48 in. dia.; 1 mud drum 36 in. dia. Babcock & Wilcox Co.

Furnace. Size 13 ft. 8¾ in. by 14 ft. 0 in. by 10 ft. 0 in. equipped with 100 per cent plastic "Ramtite" refractory supplied by The Ramtite Co. Installation by Eastern Refractories Co.

Oil Burning System. 3 burners, one arranged for burning light oil. The E. L. Wooley Co.

Oil Pumps. 2 steam driven 5¼ by 3½ by 5 in. controlled by Leslie ¾ in. pump governors. Warren Steam Pump Co., Inc.

Oil Heaters. 2, size 810. Ross Heater & Mfg. Co., Inc.

Breeching. Connery Construction Co.

Stack. Radial brick, 7 ft. dia. at top, 22 ft. dia. at base, 185 ft. high. M. W. Kellogg Co.

Boilers Fittings and Accessories

Safety Valves. Ashton Valve Co.

Stop and Check Valves. Lunkenheimer Co.

Inspirator—Hancock. Manning, Maxwell & Moore, Inc.

Reflecting Water Level Indicator. Diamond Power Specialty Co.

Feed Water Regulator. Bailey Meter Co.

Soot Blowers. Vulcan Soot Blower Corp.

Blow-off Valves. Lunkenheimer Co.

Combustion Control

Combustion Control System. Askania Regulator Co.

Smoke Indicator—"Hazegage". Ess Instrument Co.

Oil flow, air flow meter. Hays Corp.

Instruments and Meters

Main Control Panel. Steam and water pressure gages. Ashton Valve Co.

Telechron Clock. Warren Telechron Co.

Boiler Meter. Bailey Meter Co.

CO_2 Recorder and Indicator. Hays Corp.

F. W. Temperature Recorder. Bristol Co.

Multipointer Draft Gage. Bailey Meter Co.

Indicating pressure and temperature gages. Bristol Co.

Thermometers. Taylor Instrument Co.

Feed Water System

Feed Water Heater. 54,000 lb. per hr. vertical, cast iron, open heater with vent condenser. Elliott Co.

Boiler Feed Pumps. 2—centrifugal, 180 g.p.m., 370 ft. head, 1750 r.p.m. Lawrence Machine & Pump Co.

B. F. Pump Drives. 1 motor driven, 30 hp., 220/440 v. induction motor. General Electric Co.

1 steam driven, 30 hp., 1800 r.p.m. turbine. General Electric Co.

F. W. Heater Regulating Valve. Mason-Neilan Regulator Co.

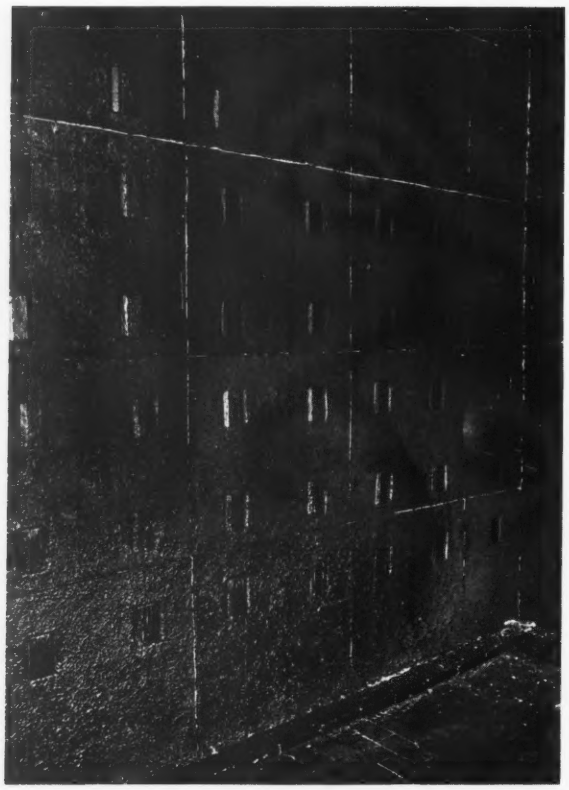


Fig. 7. A photograph of the interior of the furnace

operating floor level. The feedwater heater is installed on a floor directly above the feed pumps. This floor also contains the locker room, toilet and shower for the operators.

Control of the plant is centered on two panels, one the main instrument board and the other the Askania control panel. The latter is fitted with a Hays oil flow, air flow meter and a Hazegage photo-electric smoke indicator.

The main instrument board contains the necessary temperature, pressure and flow recorders and indicators, and is fitted with a special arrangement of Luminline lamps for lighting.

As is evident from the photographs, the plant is roomy and bright and exceptionally clean. The floors are painted with a glossy enamel and the walls are of glazed tile. The breeching which is fully insulated is installed inside and arranged for connection to the future boiler. For emergency boiler feed, a Hancock Inspirator is provided.

An element of interest attaches to the glass brick panels which provide illumination. These eliminated all windows from the building. From a lighting standpoint this was ideal, but from a ventilating standpoint it was found to produce difficulties in maintaining an adequate air supply in the room for combustion. With all the doors closed, the building was so "tight" that there was insufficient air for combustion. To provide this air, louvres were installed underneath the glass brick panels and in the outside doors.

On the whole this boiler plant is about as neat a job as any we have seen. It is as different from the old time boiler room with its sweating coal heavers as black differs from white. The operator here becomes merely an intelligent observer. Except as needed during times of overhaul or repair, labor has practically left this sort of plant. And yet, in view of the state of the art today, it is no more than every boiler plant should be.

Municipal Primer—Bronze Plaques

Simple solution of perplexing problem offered by the Milwaukee Journal reproduced because it emphasizes the growing complexity of municipal projects in large cities, a complexity which tends to hide the fundamental purpose of the work.

THE boys in the city hall are all adither over placing a bronze tablet in the filtration plant lobby, to commemorate the inception and construction of that facility.

The question seems to be, whose names shall appear on the tablet?

Well, the plant was built under one of the numerous administrations of Daniel W. Hogan, so Dan's name should head the list.

Then the architect must be remembered.

Next there's the city engineer. He worked hard to get the city's water users to assume a $4,000,000 debt, so he rates as an honored listee. But he's hired by the commissioner of public works, so Mr. Stoelting's name properly belongs on the tablet.

Then there's the superintendent of the water department, chairman of the finance committee, president of the common council, each playing a part and having a claim to fame in bronze.

Since the money for the erection came through a PWA loan and grant, Mr. Harold Ickes' name ought to appear; and since Mr. Ickes is one of Mr. Roosevelt's hired men, the president's name shouldn't be omitted.

Then there's the state of Wisconsin to be considered. To build the filtration plant meant to involve the home folks in debt and also in higher water rates—and the Wisconsin public service commission is seeing to that. So the names of the public service commissioners should appear.

The suburbs are interested and will help pay, so the names of their village presidents, trustees, boards, and treasurers should be included in the engraving.

All aldermen voted for or against the facility, so they shouldn't be forgotten. The comptroller protested certain excess expenditures, so his name deserves a place. And since the plant has country-wide significance, the names of all supervisors should be included.

In fact, since all Milwaukee water users will, for years, kick in with contributions to pay off the plant's debt, the bronze tablet really ought to be a replica of the city directory.

This seems to be the trend at present. But, if, in the interests of simplicity, the aldermen should decide on something less comprehensive, we suggest:

"Erected by the Milwaukee tax payer. He's paying for it. Anno Domini 1939."

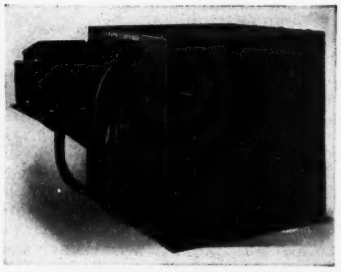
New Equipment

Information that you desire about any equipment will be gladly furnished without obligation. WRITE POWER PLANT ENGINEERING.

Fan

THE BUFFALO FORGE CO., Buffalo, N. Y., announces its new "L" Breezo Fan for application where it is desirable to install propeller fans so that the fan motor is not in the path of the air handled.

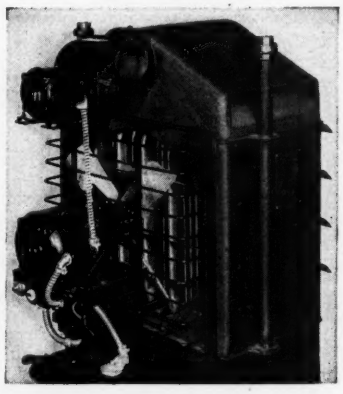
Although the stand and arrangement is with the air inlet at the bottom, it may be at the top or on either side. Motors are of ample capacity for resistance up to ¼ in. static. With V-belt



drive, it is easy to change the fan speed and motor size when conditions require more air against high resistance. The motor, V-belt, pulleys and one bearing are entirely outside the path of air being handled. The bearing at the fan end of the shaft which is in the air chamber is regularly of bronze, enclosed and wool-packed, requiring oiling about once every 2000 hr. of use. Where desired, enclosed ball bearings packed in grease can be furnished and will operate for years without attention or re-oiling.

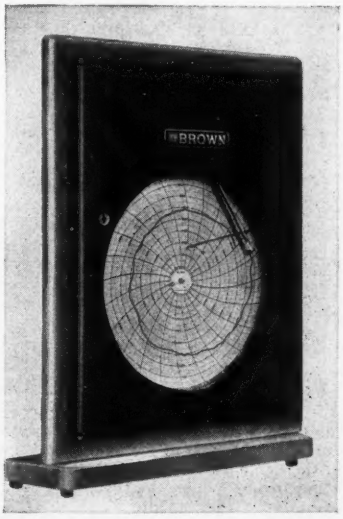
Gas-Fired Unit Heaters

A NEW series of five gas-fired unit heaters, ranging in capacities from 85,000 to 200,000 B.t.u. per hr. was announced by the Automatic Gas-Steam Radiator Co., 559 Brushton Ave., Pittsburgh, Pa. They are equipped with automatic flues which consist of a motor and blower connected in such a way that when the heater starts to work, the flue automatically carries the products of combustion through pipe and wall to the outside. The assembly includes a safety pilot which turns off the gas as the pilot goes out or burns too low to insure ignition. In addition to heating, these unit heaters may be used for other purposes such as ventilating, cooling and drying. The unit is suspended from the ceiling. The gas fires into a combustion chamber and the products of combustion pass upward into a bank of tubes, and then are automatically carried outside. Air is passed around these tubes by means of a motor-driven fan located on the back of the unit.



Thermometer and Pressure Gage

AN ENTIRELY new and improved line of temperature and pressure recorders, indicators and controllers has been announced by The Brown Instrument Co., Philadelphia, Pa. These instruments include thermometers indicating and recording types for temperatures from



—40 deg. F. up to 1200 deg. F.; and indicating or recording pressure and vacuum gages for ranges from 6 lb. of water up to 2500 lb. per sq. in. and on vacuum ranges of 10 in. of mercury and over. All types are offered in one, two or three pen models. The spiral actuating elements, especially heat-treated to insure permanent calibration, have ample pen torque without sacrificing speed of response. A special safety link between actuating element and pen provides an overload safeguard protecting the mechanism from damage if the pen is moved in either direction manually. Chart is firmly secured to driving mechanism by tapered stud and tapered chart positioning stud, eliminating chart knob and chain.

Automatic Flue Gas Analyzer

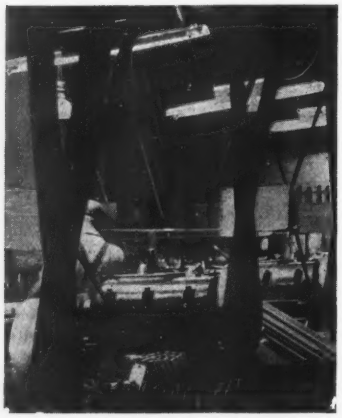
THE HAYS CORP., Michigan City, Ind., announces a new Orsatomat or Automatic Flue Gas Analyzer employing the principle of volumetric measurement and chemical absorption. The tilting analyzing unit is now composed of a transparent plastic. The new unit is smaller, lighter in weight and housed in a newly designed streamlined, pressed steel case along with a draft measuring and indicating unit. Both analyzing and indicating units are removable, and the measuring and absorption of CO_2 is done automatically through an ingenious use of mercury.

While the Orsatomat may be had simply for analyzing for CO_2 it usually is wanted with the draft measuring unit and flue gas thermometer. A two-unit model is also to be had for CO_2 and O_2 and a special model for use in testing the efficiency of automobile engines.

The Orsatomat is easily portable as it weighs but 12 lb. fully charged. It is finished in gray lacquer with chromium trim. It is employed in the smaller steam power plants to test flue gas for CO_2, in the larger plants for checking CO_2 meters as well as analyzing flue gas direct, in steel plants for checking heat treating atmospheres and by heating and service engineers in testing domestic oil burner and stoker installations.

Transmission Belt

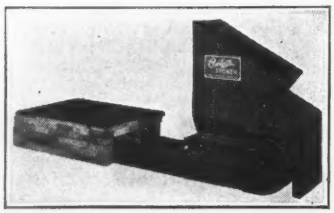
HEWITT RUBBER CORP., Buffalo, N. Y., announces an all-Neoprene friction surface transmission belt that will withstand the destructive action of mineral oils on the rubber friction compounds. Oil naturally accumulates on the transmission belts, especially where cutting fluid, which contains oil, splashes around the machine and onto the belt. Thus after considerable research and experimentation, Hewitt technicians



have developed its Duroil Hewprene Transmission belt to meet these conditions. There is no natural rubber in these belts, the friction and skim compounds being of Neoprene synthetic oil proof material. Hewprene, Hewitt trade name for products containing Neoprene, a Du Pont base, friction and skim coat of rubber between all plies provides high flexing life over high speed pulleys. The friction and skim coat protects the cotton duck against wear, ply separation, and softening from oil at high temperatures.

Small Stokers

CANTON STOKER CORP., Canton, Ohio, announces the introduction of a newly improved line of worm type underfeed stokers, built especially for commercial and smaller industrial plants. Tests have been conducted on these units over a period of 2 yr. to give a quiet, efficient and durable stoker. The speed reduction is achieved by means of V-belts and alloy steel cut gears. Motors are enclosed and cushioned on rubber. A unique feature is the sectionally built feed worm which prevents warping, lasts longer and can be replaced in parts as required. If one part of a single worm was worn, the entire unit had to be replaced. The side ash pump plates provide more active grate area and permit the stoker to be internally cleaned without raising a cloud of ash dust and clinker fumes in the boiler room.



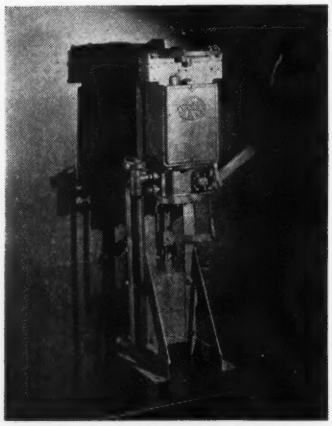
In addition to the company's standard line of temperature and pressure controls, an oudoor thermostat is offered to anticipate outside weather changes and build up a heat reserve and to provide for any contingency. Five sizes are offered ranging from a minimum of 70 lb. of coal per hr. to a maximum of 750 lb. of coal per hr.

Slime and Algae

IMPORTANCE of controlling microorganism growths which clog water passages in most cooling tower systems was the incentive for the development by the Monsanto Chemical Co., St. Louis, Mo., of a toxic agent to meet the requirements for an industrial algicide. Cantobrite, the sodium salt of pentachlorphenol, has been developed for this purpose. It is usable in all cooling water systems where the water is not used for drinking or bathing purposes and where there is not too great a loss to overflow; highly toxic to slime and algae organisms; non-corrosive to metals; compatible with other chemical treatments given cooling water; and is easily applied. It is described in detail in Bulletin G-15.

Hydraulic and Pneumatic Type Regulators

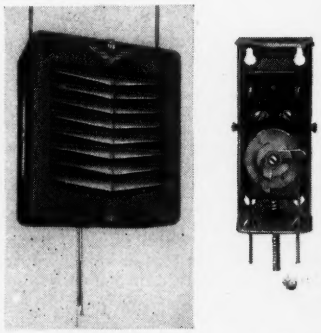
NEW Republic-Smoot hydraulic and pneumatic type regulators made by the Republic Flow Meters Co., 2224 Diversey Parkway, Chicago, Ill., incorporate several new features, such as measuring elements equipped with adjustable weighbeams, provisions for remote hand control and standardized designs of supporting stands. The adjustable weighbeam is designed to facilitate adjustments of ratios between any two controlled quan-



tities, such as fuel-air ratios or proportions of gases and to meet any conditions in the controlled system, all adjustments being made while the regulator is in operation. The remote hand control is designed to allow the individual regulator and its power piston and controlled device to be positioned manually from a remote point such as an instrument and control panel. The new regulators are regularly furnished mounted, with their power cylinders and accessories, on welded structural steel stands, as shown. Full details in Data Book S-13.

Automatic Control

BUILT-IN individual automatic control of both day and night time temperatures is now provided in Grinnell Automatic Thermolier unit heaters, made by Grinnell Co., Inc., Providence, R. I. The control is also easily added to existing unit heaters of any make, as it requires merely to be tied into the line at the heater itself.



Mounted within the heater housing is a bulb-type thermostat containing a solid liquid charge, which is the heart of the device. Two pointers—one for day, one for night—are quickly adjusted over a 60 deg. range by someone in authority and locked. Thereafter, day and night settings are made by a simple pull-cord control hanging from the heater. A special setting makes possible summer operation of the fan alone, under automatic thermostat control, without additional wiring or other changes.

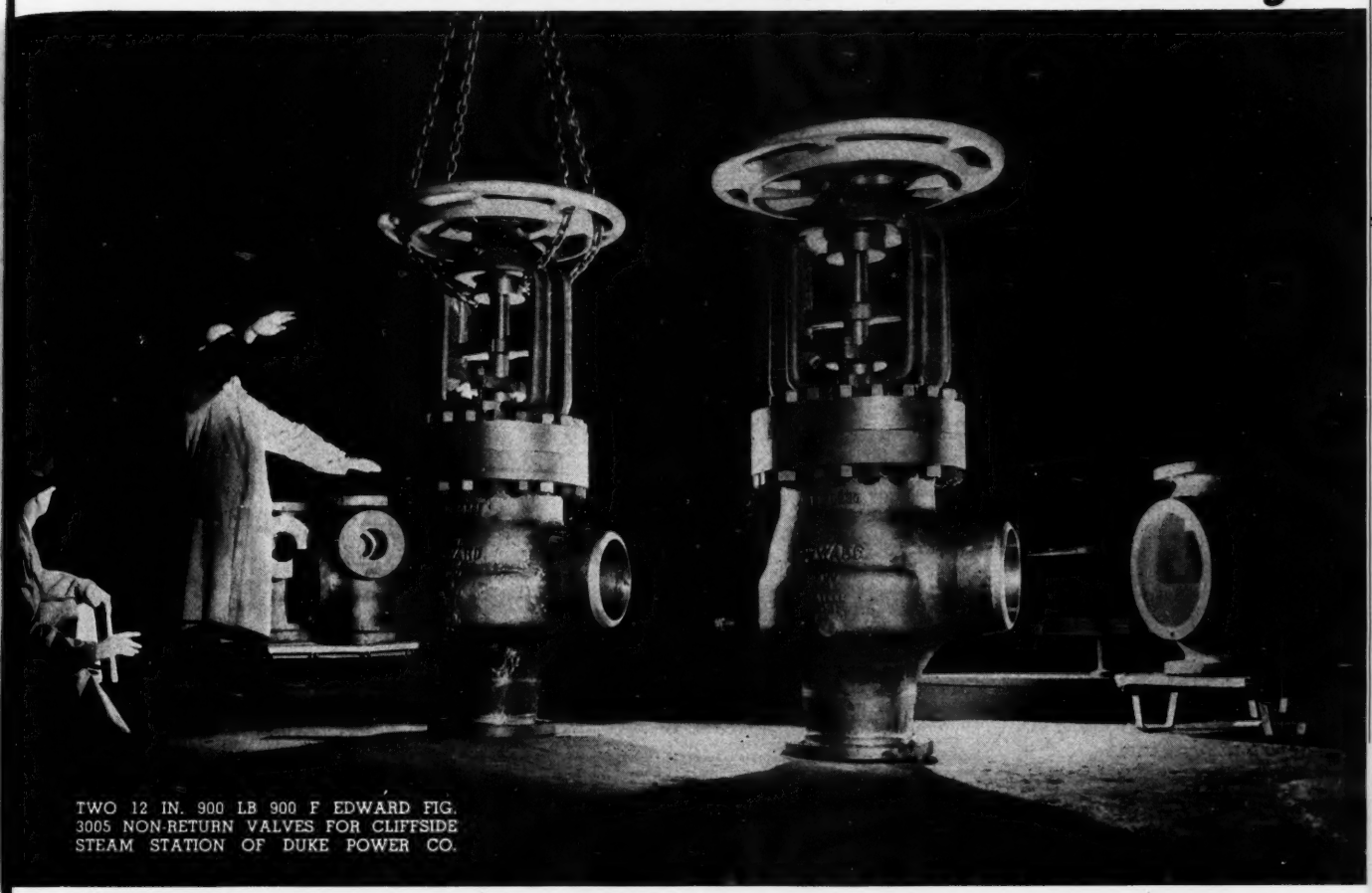
Acoustic Phone Booth

MODERN design and scientific acoustic construction are combined in this new model Burgess Acousti-Booth recently introduced to industrial, commercial, and public pay-station telephone users. This new booth, known as Model 203, offers the same sound-suppressing efficiency and privacy to the user that

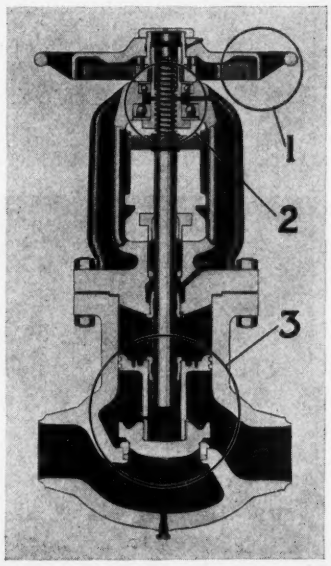
is found in the present models now in use in hundreds of noisy factories, mills, and power houses. Model 203 Acousti-Booth is made of plywood with walnut finished exterior.

Alfonso Ianneli, noted industrial designer, created Model 203 Acousti-Booth for the Burgess Battery Company, Acoustic Division, Dept. NR, 500 W. Huron Street, Chicago, Illinois.

..and, best of all, Edward Non-Return Valves Save Money



TWO 12 IN. 900 LB 900 F EDWARD FIG. 3005 NON-RETURN VALVES FOR CLIFFSIDE STEAM STATION OF DUKE POWER CO.



THREE EDWARD WINNERS

Designed for tomorrow's record-setting power plants, new Edward non-return valves embody refined but time-tried basic principles worked in with new but proved materials. Cross section shows three valuable details—(1) Impactor handwheel, (2) EValthrust yoke bushing, and (3) hourglass disk-piston assembly. Edward Impactor handwheel is a "must" auxiliary for speedy emergency operation and for leakless closure during boiler tests. EValthrust yoke bushing, with angular thrust ball bearings, is distinctively of globe valve origin. Cut shows a Stellited seat welded in the globe body.

WHEN you install Edward non-return valves you do more than post sentinels at the outlet of steam generating units. These valves, used predominantly in high pressure boiler plants throughout the land, meet all routine needs in the way of preventing back flow or of providing positive shut-off when the boiler is down. They are available for all working conditions, are often adopted to good effect for unusual flow control problems in technological processes and, best of all, they save money by their freedom from operating trouble, low up-keep cost, and minimum pressure drop. Every Edward non-return valve embodies the essentials of free flow areas, open self scouring guides, EValloy piston rings, integral dashpot with freedom from differential thermal expansion problems, and hourglass pistons. These features characterize the two welding end valves above, photographed before removal of inlet test flanges. On your next job, specify Edward valves.

THE EDWARD VALVE & MFG. CO., INC.
EAST CHICAGO **INDIANA**

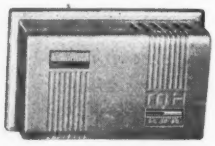
EDWARD Valves

STOP · CHECK · BLOW-OFF · NON-RETURN
FEED-LINE · RELIEF · BLEEDER LINE · ETC.

East Chicago, Indiana

Temperature Control

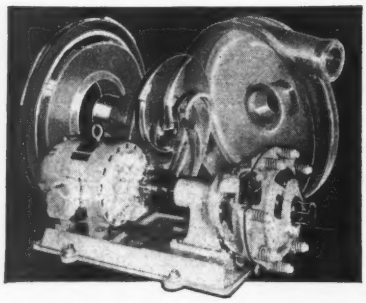
In its T0900 grad-u-skat, the Minneapolis-Honeywell Regulator Co., Minneapolis, Minn., offers a thermostat with pneumatic control of air motors and valves, claiming for it small air



consumption, great sensitivity, adjustment for direct or reverse action over wide limits, large control capacity, direct relation between temperature and air pressure, enclosed parts which are easily replaced, and long life.

Pump of Glass

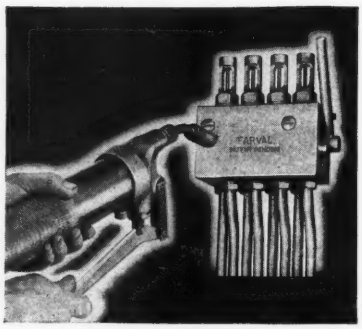
An entirely new kind of pump, The Nash Glass Centrifugal, has the mechanical advantages of metal and the chemical advantages of glass. It was conceived by the Corning Glass Works, designed and manufactured by the Nash Engineering Co., South Norwalk, Conn. Made of "Pyrex" brand heat and shock resisting glass, pump impeller and casing are not affected by temperatures up to 150 deg. F. in standard design, and 200 deg. F. in special design. Hot acids, or brine cooled liquids may be pumped with equal facility.



Cleaning when required is quickly done, for the whole interior may be laid open in a few minutes. Reassembly, after cleaning, is accomplished as quickly and the proper adjustment is practically automatic. When cleaning, acid solutions may be used without fear of injuring or pitting the hard chemical resistant "Pyrex" brand glass of which the pump is made.

Multiple Measuring Valve

For lubricating small machines or a few bearings on larger machines from a single grease inlet, a new system has been developed by The Farval Corp. of Cleveland, O. This new DX Multiple Measuring Valve, combines a single inlet port with 2 to 8 outlets per block. As many valve blocks as may be needed to lubricate all bearings on a machine can be installed and connected in series. Positive, pressure lubrication of every bearing is accomplished by connecting a conventional type of hand or power grease gun to the grease nipple at the inlet port.



Movement of the tell-tale indicator stem attached to each valve piston shows that each bearing has received its measured amount of lubricant. The amount of lubricant delivered is individually adjustable and not a bearing is missed.

Elevator Application of Electric Hoist

Where the volume of business doesn't warrant a large investment for general elevator service, yet is large enough to demand a speedier and efficient plan for handling materials, it might well serve the purpose to use the P. & H. Hevi-Hoist made by the Harnischfeger Corp., Milwaukee, Wis. As shown in the illustration, the P. & H. electric hoist

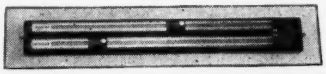
is installed permanently over a small elevator well and is used to lift and lower materials in portable boxes from the basement to all floors. The push-button control permits easy operation at all floor levels, helps maintain a smooth flow of materials from the receiving department to the manufacturing floors and back to the shipping room.

Colloids

Industrial Colloids Corp., 1316 W. Cermak Road, Chicago, Ill., announces a new line of industrial colloids compounded for various mechanical purposes, including a high temperature lubricant, a high temperature joint compound, a plastic gasket, as well as a packing compound intended for application on all types of fibrous or metallic packing which is said to materially assist in glazing off the packing used and to supply an extremely long lasting lubricant in the stuffing box. It is claimed that an effective seal is attained with a minimum of friction, and that the possibility of scoring, because of the metallic glaze imparted to the packing as well as to the moving member, is considerably reduced if not eliminated.

Inexpensive Wheatstone Bridge

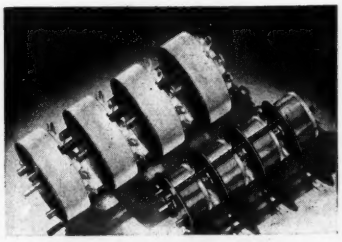
The Broome Bridge, developed by Frank H. Broome, is a compact, modified form of Wheatstone bridge. Although the bridge was designed largely for educational use, it is of such form that there are many places in industry where it might be used. This bridge employs separate ratio arms whose



lengths are independently variable. Its circuit therefore, follows the classical Wheatstone bridge diamond, within which all binding parts are conveniently grouped. The instrument measures only 24 in. overall. Each ratio arm consists of a pair of parallel resistance ribbons enclosing a scale. These ribbons may be connected at any point by moving a rider which makes positive, pressure contact. It is accurate, can be read at 0.1 per cent, and is inexpensive. Cambosco Scientific Co., Boston, Mass.

Tandem Assemblies For Tap Switches

Tandem assemblies of 2, 3, 4, or more of the new Ohmite Power Tap Switches are now made available by the Ohmite Mfg. Co., Chicago. These tandem assemblies are used to switch both sides of a single-phase line or to switch all phases of a 3-phase line; to provide simultaneous control of separate circuits and for other applications. Ohmite power tap switches—coupled together by special extended shafts—are used in these tandem units. They are compactly assembled and held rig-



idly together by through-bolts and insulated spacers. Easily mounted on panel by 3 screws.

Four sizes of Ohmite Power Tap Switches are available for single or tandem mountings: Model 212, 10 amp., 240 v. A.C., diam. 2¼ in. Model 312, 20 amp., 240 v. A.C., diam. 3⅛ in. Model 412, 40 amp., 240 v. A.C., diam. 4⅛ in. Model 608, 75 amp., 240 v. A.C., diam. 6 in. Data Sheet 114 gives all information on single and tandem units. Ohmite Mfg. Co., 4835 Flournoy St., Chicago, Ill.

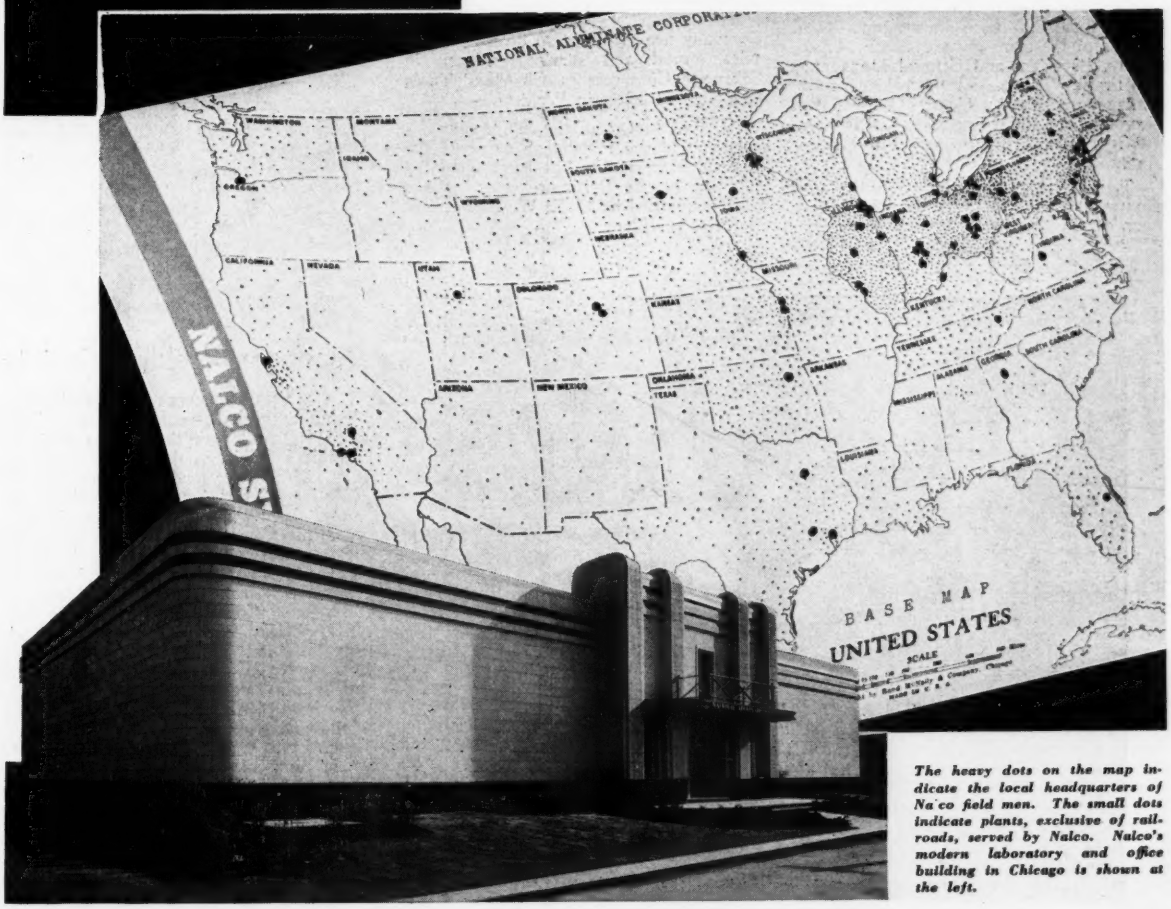
NALCO SERVICE COVERS THE COUNTRY

NO MATTER in what part of the country you are located, Nalco service is near at hand to bring you the Nalco System of Feedwater Treatment. As shown by the accompanying map, in most places you will find long-time Nalco customers all around you—plants so prominent that if you judge Nalco by the company it keeps, you will accord it highest rank. If you would like to ask users near you what they think of the Nalco System, we will be glad to furnish you with names on request. Write.

NATIONAL ALUMINATE CORPORATION

6224 W. 66th Place — Chicago, Illinois

Inquiries other than domestic, except those from U. S. Possessions, Canada and Mexico, should be addressed to ALFLOC, LTD., Bush House, Aldwych, London, W. C. 2, England. Canadian inquiries should be sent to ALUMINATE CHEMICALS LTD., 372 Bay Street, Toronto, Ontario.



The heavy dots on the map indicate the local headquarters of Nalco field men. The small dots indicate plants, exclusive of railroads, served by Nalco. Nalco's modern laboratory and office building in Chicago is shown at the left.

News from the Field

CHAIN BELT CO. of Milwaukee has acquired the business and all of the net assets of the Baldwin-Duckworth Chain Corp. of Springfield, Mass. The merger grew out of a selling arrangement between the two firms. There is little overlapping of products, thus, Chain Belt's line is rounded out by the addition of finished roller and automotive timing chains, cut tooth sprockets, flexible couplings and certain types of light conveyor chains.

SYMPOSIUM on temperature, its measurement and control in science and industry will be held in New York City at the Pennsylvania Hotel, November 2 to 4, by the American Institute of Physics, 175 Fifth Avenue, New York, with the cooperation of the National Bureau of Standards, the National Research Council, and officers and committees of many technical societies.

THE APPOINTMENT of a new committee to have the responsibility for the policies and co-ordination of advertising is announced by Charles E. Wilson, executive vice-president of General Electric Co. Chester H. Lang, B. W. Bullock and H. F. Barnes are members of the committee.

GENERAL PIPING CORP. has established its headquarters office in Detroit. The officers of the company are: G. Howard Boddy, President and General Manager; C. Frank Troop, Vice-President and manager of Sales; Henry C. Moffett, Secretary and Chief Engineer; and Joseph H. Spurgeon, Treasurer and Purchasing Agent.

THE HAGAN CORP. announces the appointment of J. T. McFarland as Manager of the St. Louis branch office for Hagan and its subsidiary companies, Hall Laboratories, Inc., The Buromin Co. and Calgon, Inc. Mr. McFarland comes to Hagan Corp. with a twenty-two year background of successful sales engineering. He graduated from Purdue University in 1919 with a B.S. degree in Mechanical Engineering. From that time till 1937 he was connected with the Worthington Pump and Machinery Corp. in various engineering and sales work. At that time he accepted a position with Lycoming Manufacturing Co. as sales manager.

SCHRAMM, INC., West Chester, Pa., Manufacturers of portable and stationary air compressors announce the appointment of George B. Comfort as Manager of Sales Promotion. Mr. Comfort has been associated with Schramm since 1924, having served in the capacity of Factory Manager, and more recently as Manager of Engineering Sales.

JOSEPH E. MCGROGAN has accepted the position of Manager of the Schramm Department of Equipment Rental Company, 3717 Filbert Street, Philadelphia, Pa. Mr. McGrogran has been associated with Schramm since 1918, most of the time as Office Manager of the Philadelphia Branch, 709 Arch Street, under District Manager, T. H. Jayes, Equipment Rental Company are prepared to do a complete sales, rental and service business in Schramm Compressors, Cleveland Tools and General Electric Welders.

G. P. AIRHART, of the engineering department at the Pittsburgh office of the General Electric Co. has been appointed engineer at the Baltimore office, it has been announced by C. K. West, commercial vice president.

After graduating from the University of Pennsylvania in 1923 with a B. S. degree in electrical engineering, Mr. Airhart entered the employ of the company in March, 1924, in the student test course at Schenectady. In 1925 he joined the construction force at the Philadelphia office, and five years later went to the Pittsburgh office in the engineering department.

RILEY STOKER CORPORATION announces the establishment of its Chicago office, Marquette Building, Chicago, Illinois. This office will be in charge of A. L. Mitchell, Jr., District Manager and Thane R. Halstead, Assistant District Manager. Both Mr. Mitchell and Mr. Halstead have had extensive technical training and sales engineering experience in this territory.

APPOINTMENT of R. S. Neblett as assistant manager of the turbine division of the General Electric Co. has been announced by C. S. Coggeshall, division manager. Mr. Neblett has been connected with the turbine division of the company since March, 1926, and has been manager of sales of the Schenectady section since March 1, 1938.

He has been with the company continuously since June, 1923, when he entered the test department immediately following his graduation from Georgia Tech in that year with the degree of bachelor of science in electrical engineering.

TENTATIVE plans for an Air Conditioning Conference to be held at Lehigh University November 10 and 11, under the sponsorship of The American Society of Refrigerating Engineers, have already been formulated, and the cooperation of other engineering groups is expected in this event. Prof. B. E. Jennings of Lehigh University is in general charge of the Conference, and will be ready to announce definite topics and the names of speakers within the next month. Other members of the Conference committee are: C. C. Williams, president of Lehigh University, honorary chairman, Willis H. Carrier, A. C. Callen, William B. Henderson, John Hertzler, S. R. Lewis, J. L. Rosenmiller.

American Welding Society

WELDING ENGINEERS and metal-fabricating executives, supervisors and foremen from all over the country will assemble in Chicago during the week of Oct. 23-27 to attend the 20th Annual Meeting of the American Welding Society. Interesting discussions on Government in Construction Work, Industrial Research, Production Welding in Light Gage Material, Fundamental Research, Machinery Construction, Welding in Equipment Construction, Flame Hardening and Hard Surfacing, Resistance Welding, Welded Piping, Pressure Vessels and Boilers, Cutting and Welding in Steel Mills and Welding in Structural and Ship Work will be heard at the meeting. The following nominees will be formally inducted into office: President, G. T. Horton; First Vice-President, T. C. Smith; Second Vice-President, L. S. Moisseiff. The photograph at the left shows an excellent example of the type of machinery fabrication made possible by welding. This departure in the building of heavy Diesel engines was pioneered by the Electro-Motive Corp., LaGrange, Ill.

LUNKENHEIMER
Fig. 1640 'KING-CLIP'

"THE KING OF CLIP VALVES"

Fig. 1640 is the original clip valve with drain channels and bronze thread bushing in bonnet.

The exterior construction clearly indicates the large drain channels; of ample size to thoroughly drain the bonnet of even fluids which tend to clog.

The bronze thread bushing cast in the bonnet has excellent wearing qualities and provides non-corrodible contact for stem.

Fig. 1640 "King-Clip" also has other important features:-

Bronze stem – perfectly aligned, with repacking seat above threads.

Extra strong stuffing box with hexagon head gland.

Bronze disc and rolled-in bronze seat rings – bronze to bronze contacts throughout which prevent corrosion.

ESTABLISHED 1862

THE LUNKENHEIMER CO.

"QUALITY"

CINCINNATI, OHIO, U. S. A.

NEW YORK CHICAGO
BOSTON PHILADELPHIA

EXPORT DEPT. 318-322 HUDSON ST., NEW YORK

CARRIED IN STOCK BY LUNKENHEIMER DISTRIBUTORS

5-82-44

DUE to the outbreak of the war in Europe the Machine Tool Show which was to have been held at Cleveland, Ohio, on Oct. 4 to 13 has been postponed indefinitely. This also involves the postponement of the Machine Tool Congress, a series of meetings which were sponsored by a group of nine engineering and technical societies, and which were to have been held during the Machine Tool Show. The members of the National Machine Tool Builders Association feel that they should concentrate their entire efforts on the production of the greatest possible number of machine tools.

C. DONALD DALLAS, President of Revere Copper and Brass Inc., announces the appointment of R. Carson Dalzell as Technical Advisor to Revere's Baltimore Division, with headquarters at 1301 Wicomico Street, Baltimore, Md. Mr. Dalzell, after graduating from Johns Hopkins University as Bachelor of Engineering, entered the Graduate Engineering School of Harvard University and received the degrees of Master of Science in nonferrous metallurgy and Doctor of Science in metallurgy. He then entered the Central Research Laboratory of the American Smelting and Refining Co. and upon resignation from that position in 1931, was engaged for a period of one year on process development with Ajax Metal Co., Philadelphia. After a year of consulting work, Mr. Dalzell was employed by the American Oil Co., Baltimore, until he came to Revere in September 1937.

JOHN F. COLLINS, JR., long associated with the district heating industry, and for a number of years employed by the Allegheny County Steam Heating Co. of Pittsburgh, has been appointed by the executive committee as Secretary-Treasurer of the National District Heating Association. He will make his headquarters at the new headquarters of the Association at 1231 Grant Bldg., Pittsburgh, Pa.

MORRIS E. LEEDS, founder and president of the Leeds & Northrup Co., has assumed the position of Chairman of the Board of Directors, and Charles S. Redding, Vice-President in Charge of Research and Engineering, became President, in an expansion of the Company's executive set-up in July. Chairman of the Board is a post newly created to facilitate Mr. Leeds' participation in policy matters with which he will continue active.

This promotes to the presidency of the Company one who has spent with it almost his entire business life. Mr. Redding took his first position with Morris E. Leeds & Co., predecessor of the present firm, for 15 months between high school and college. Receiving a B.S. in E.E. from the University of Pennsylvania in 1906, he spent 2 years as instructor in mechanical engineering there, and was briefly associated with the Engineers Club of Philadelphia. He rejoined the Company in 1909, by which time it had become Leeds & Northrup Co., and has since held executive positions in every division of its activities. He became 2nd vice-president in 1918, was treasurer from 1922 to 1924, and became vice-president in charge of research and engineering in 1928.

MORRIS MACHINE WORKS Baldwinsville, N. Y., announces the appointment of M. H. Morris as President, J. L. Lonergan as Vice-President and General Manager, A. G. Forssell as Second Vice-President, and the reappointment of R. S. Mercer as Secretary and Treasurer. All of these officials have been associated with the Company for many years.

WALTER S. FINLAY, JR., for many years associated with American Water Works & Electric Co. as vice-president and director, and latterly president of their West Penn Electric Co., is resigning from these connections and is joining the J. G. White Engineering Corp. as vice-president.

THE CONNEAUT PACKING CO., Conneaut, O., announces the election of D. R. Ingraham of Townville, Pa., to the presidency of the company, taking the place of C. Vern Carr.

AT A meeting held on August 29, the Board of Directors of Union Carbide and Carbon Corporation approved an agreement for the acquisition by Carbide of all the assets of Bakelite Corp. The consummation of the agreement will bring valuable supplementary facilities to both organizations. The coordination of technical knowledge, research, production methods, and distribution facilities of these two organizations will result in the improvement of existing products, the development of new plastics and other chemical compounds, and the discovery of new uses for such materials.

ARRANGEMENTS have recently been completed whereby the Diesel engines of R. A. Lister & Co., Ltd., Dursley, England, and of Blackstone & Co., Ltd., Stamford, England, will be built in the United States by Le Roi Company of Milwaukee. Lister and Blackstone engines are available in both vertical and horizontal types in a wide range of sizes. Your inquiries for Diesel engines should be addressed to Lister-Blackstone, Inc., Milwaukee, Wis.

ROBINS CONVEYING BELT CO. announces it has been awarded a contract for furnishing and installing the conveying equipment to convert the former U. S. Collier Jason to a self unloading vessel. The Jason is now owned by Boland & Cornelius, Inc. As reconstructed, the capacity of the S. S. Jason will be 10,000 gross tons of coal and unloading will be accomplished through more than 80 gates discharging to a pair of 42 in. wide belt conveyors 286 ft. long. Each belt will have a capacity of 700 t. per hr. These with the shuttle conveyors and elevators permit the boat to unload a complete cargo in from 6 to 8 hr.

THE FOURTH regular meeting of the Industrial Unit Heater Association will be held in Chicago, Ill., on October 6, 1939. It is expected that the standardization program of electrical equipment undertaken jointly with the manufacturers of fractional horsepower motors will be considered as well as a further report on the subject of corrosion in steam heating systems.

CONTRACTS for the design and construction of a $150,000 addition to the Wellsville, New York, plant of the Moore Steam Turbine Co., subsidiary of Worthington Pump and Machinery Corp., have been awarded to The Austin Co., engineers and builders. The addition will be devoted to the testing and erecting of steam turbines, and was made necessary by the increased volume of business. The building is to be completed in November.

CHARLES MCDONOUGH, Advertising Manager of the Combustion Engineering Company, New York City, was elected President of the National Industrial Advertisers Association September 22 at the closing session of the 17th annual Conference held at the Hotel New Yorker, New York City, September 20 to 22. The following Vice Presidents were elected: Richard P. Dodds, Truscon Steel Co., Youngstown, Ohio; William D. Murphy, Sloan Valve Co., Chicago; Herbert V. Mercready, Magnus Chemical Co., Garwood, N. J.; E. J. Goss, The Koehring Co., Milwaukee, Wis.; Terry Mitchell, Frick Co., Waynesboro, Pa.; and H. S. Van Scoyoc, Canada Cement Co., Ltd., Montreal, Quebec, Canada. Ralph Louis Towne, Surface Combustion Corporation, Toledo, Ohio, was elected Secretary-Treasurer.

For the Engineer's Library

Recent bulletins and catalogs on power plant equipment listed for your convenience in securing specific information. Power Plant Engineering will be glad to procure for you any free literature that you desire.

Controls, Meters and Instruments

Thermocouples and Accessories—A 36-page illustrated bulletin No. 235 under this title is divided into conveniently arranged sections describing the different kinds of thermocouples, thermocouple assemblies and parts made by Foxboro. Detailed specifications for various types of thermocouples are included, with full information as to the temperature ranges, and other thermal and mechanical conditions affecting the use of special types. The Foxboro Co.

Controls—Bulletin No. 72-D describes a very complete line of type "M" instrument, control and auxiliary switches. Features are the unit type construction permitting assembly of any number of stages, and the flexible four-way operation—right-left or push-pull. Seventy control diagrams are illustrated. Delta-Star Electric Co.

Brown Boiler Room Instruments is the title of a new book No. 29-31 providing data from which a suitable plan of instrument equipment, covering most operating needs, may be easily worked out for any steam plant. Feedwater temperature, saturated steam flow, and percent CO_2 tables point out the possibilities in fuel saving, the primary object of improved boiler-room efficiency. Steam generation and distribution applications for measuring temperature, pressure, flow, liquid level and percent

"WE LEARNED LAST YEAR that one of the surest ways to help lick the welfare problem in our town was for the manufacturers to pull together with the merchants; to stimulate trade and prosperity by buying everything possible right here at home.

"Take our own case. Our chief engineer found that he could purchase, among many other items, top-quality mechanical packings from the mill supply house just down the street. Formerly he sent hundreds of miles away for them. Now he gets quicker deliveries, and he tells me these Chesterton Mechanical Packings are the best he has ever used. One packing alone, "64" for steam rods, has saved us many dollars.

"More important, we feel that this buy-at-home policy promotes a better civic spirit and helps plow back into our own community what we have earned here."

Decide now to be not only a good neighbor but a valuable one. Call in your local Chesterton trained mill supply salesman on your next packing job. He has been selected to serve your community because of the knowledge and experience he has gained in the mechanical packing field—whether the job is hydraulic, steam, oil or ammonia he can make the correct Chesterton recommendation. The 55-year old Chesterton Company stands squarely back of his money saving suggestions.

There is an interested Chesterton distributor in your locality. If you do not know who he is, write us. We will gladly furnish his name.

A. W. CHESTERTON COMPANY

64 India St., Boston, Mass.

PACKING Chesterton SERVICE

Top-Quality Features:

1. **Self-setting**
2. **No rubber back**
3. **Diagonal asbestos plies**
4. **Non-hardening binder.**

Order Today

through *your* Local Jobber

ALL CHESTERTON DISTRIBUTOR SALESMEN ARE FACTORY TRAINED

CO_2 are illustrated and described. The Brown Instrument Co.

Pressure Regulators—Catalog No. 40 contains 60 pages giving description and list of many of the types of gas pressure regulators made by The Chaplin-Fulton Mfg. Co.

Demand Registers for Watthour Meters—Indicating demand meters that result from combining new registers and special covers with the standard watthour meters are described in a 48-page booklet, Catalog Section 42-35. Dimensions, prices and application data are included, as well as a listing of available portable testing devices. Westinghouse Electric & Mfg. Co.

Meters — Indicating and recording demand meters that measure block-interval kv-a. demand under all conditions of load and power factor are described in a 24-page booklet, Catalog Section 42-414, issued by the Westinghouse Electric & Mfg. Co.

Electrical Equipment

Coils and Transformers—A new catalog featuring custom-built solenoids, coils and transformers has been issued. Graphs giving technical information, plus illustrations of some of the many applications of solenoids to modern machines are included. Dean W. Davis & Co.

Electrical Equipment — Nine new bulletins on various types of electrical equipment have been issued. They cover the following subjects: Bulletin GEA-2420, capacitor-motors; Bulletin GEA-3085A, Spirakore distribution transformers; Bulletin GEA-2426B, outdoor oilblast circuit breakers; Bulletin GEA-2596A, metal-enclosed switchgear; Bulletin GEA-2539B, Type AL-2 air circuit breakers; Bulletin GEA-1662C, Type AL-2 air circuit breakers; Bulletin GEA-3236, Percentage differential relays for transformer protection; Bulletin GEA-3237, Pilot-wire relays, Type IJD; Bulletin GEA-2018B, Induction voltage regulators, Type BIRS. General Electric Co.

Rheostat—The new Jagabi Lubritact Rheostat is illustrated and described in Bulletin 1620. An explanation of the lubricated sliding contact is given in the bulletin. James G. Biddle Co.

Relays—Type DT-1 Thermo-Magnetic Relays, designed for motor, generator and transformer protection is the subject of Catalog 12-A. Roller-Smith Co.

Circuit Breaker—Bulletin B 6016 illustrates and describes type TLB load-ratio-control equipment used on large and high voltage power transformers. The TLB mechanism described is applicable for voltage or phase angle control. Allis-Chalmers Mfg. Co.

Reliance V S Drive, an all electric adjustable speed drive for alternating current circuits is illustrated and described in Bulletin 307. Reliance Electric & Engineering Co.

Mechanical Power Transmission

Silent Chain Drive—The new Whitney V-135 Silent Chain Drive Catalog gives complete information for the selection and design of silent chain drive. It includes 64 pages of engineering data, dimensions, horsepower ratings, and sprocket data, as well as illustrations and typical drive in various industries. Whitney Chain & Mfg. Co.

Worm-helical Speed Reducers are covered in a new 16-page bulletin giving general description, horsepower ratings and dimensions. W. A. Jones Foundry & Machine Co.

Chain Sprockets—Bulletin 60-A contains 139 pages and covers chains, sprockets, gears, belt conveyor idlers, elevator buckets, feeders, valves and other similar products. All equipment is illustrated and described, giving prices, sizes, specifications and applications. Webster Mfg. Co.

Gears—Two new sizes of P.I.V. gear variable speed transmission units have been included in a new 40-page book No. 1574, seventh edition. Other new items included in the book are vernier control for extra-fine speed variations; and a convenient table that makes it easy to select the proper size unit for the service. Link-Belt Co.

Vari-Pitch Speed Changer—Bulletin B 6013 presents a well prepared story by pictures and facts to show how these speed changer units help in "Keying Production to Profits." Many installation views, shop assembly pictures are included. The bulletin covers manual and electrical remote controlled units, dimension sheets, horsepower and speed range tables. Allis-Chalmers Mfg. Co.

Manhattan Rubber Products for Industry is the title of a catalog describing hundreds of mechanical rubber products and special items manufactured by Manhattan. Particular emphasis is given belting, hose, packing, molded rubber goods, industrial asbestos friction material, rubber roll coverings, tank linings, and abrasive wheels. The catalog also contains transmission belt engineering data and technical information on other products. The Manhattan Rubber Mfg. Division.

Boilers and Accessories

Continuous Blowdown—The Henszey System of Continuous Blowdown for complete automatic control of boiler water concentration without heat loss is the subject of a new bulletin. Henszey Co.

Water Columns and Gages are the subjects treated in Bulletin WG-1807. Construction details, repair parts, prices and dimensions are covered in the bulletin. Three pages of typical installation views are also included. Yarnall-Waring Co.

Boiler—A new 14-page bulletin gives the details of construction of the forged steel sectional header type boiler. Several drawings of representative installations of this type of boiler are included in the bulletin. Henry Vogt Machine Co., Inc.

Storage Tank Oil Heater—A new bulletin 1640 describing a storage tank oil heater with fin-type heating elements explains how the G-Fin heat transfer surface makes the unit far more effective and compact than heating apparatus with plain tubes or pipes, and describes in detail additional advantages such as the ease of removal of individual heating elements. Sketches and photographs show alternate arrangements of the unit for installation outside or partially in a tank. The Griscom-Russell Co.

Valves

Valves — Single-pressure hydraulic valves for pressures up to 5000 lb. are illustrated and described in Bulletin H-209. Construction features, sizes, dimensions and prices are included in the bulletin. Yarnall-Waring Co.

Valves—A new folder illustrates and describes a brand new line of Fairbanks Bronze Gate Valves giving prices and dimensions. The Fairbanks Co.

Miscellaneous

Resurfacer—Over the Rough Spots is the title of a booklet which is plainly illustrated to find quick answers to building maintenance problems. The booklet illustrates and describes Stonhard Resurfacer and shows its application in building maintenance. Stonhard Co.

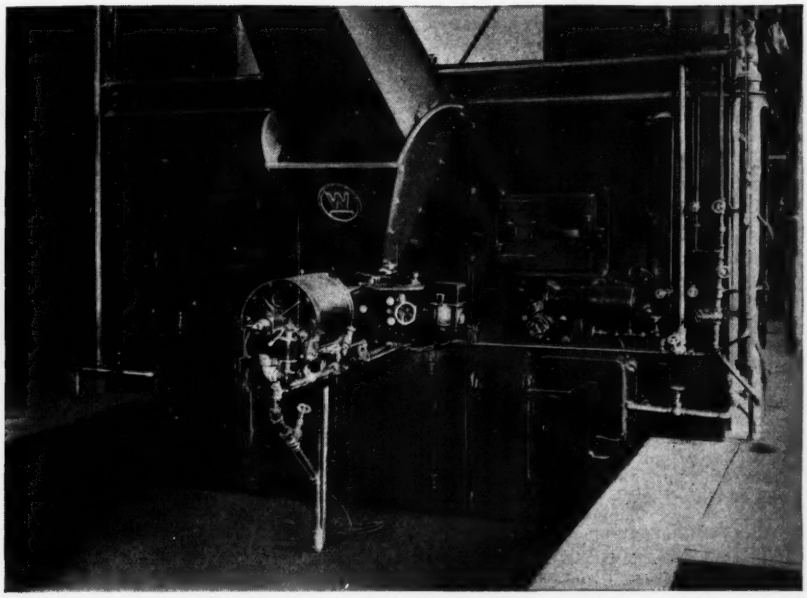
Building & Operating Costs — A graphic comparison of relative building and operating costs in single story and multistory industrial buildings, and a discussion of their relative advantages and disadvantages in the fifth edition of its booklet, "Your New Plant—Multistory or Single Story—Which?" The Austin Co.

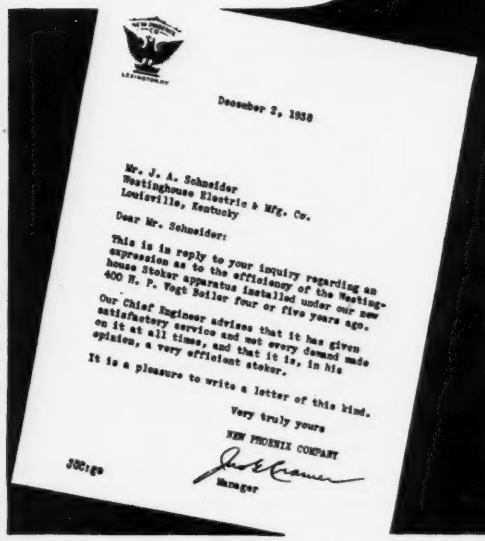
Compressor — Bulletin C 1100-B5 illustrates and describes Worthington Carbondale refrigeration compressors which are vertical duplex double acting with enclosed crankcase. Carbondale Div., Worthington Pump and Machinery Corp.

Would You Like Any of These Bulletins for Your File?

To secure this information all you need to do is to mail the filled-in self-addressed business reply card printed at the bottom of the colored bulletin summary page published in this issue. State the number of the page on which the item is published, the name of the company offering the literature, and the bulletin number, catalog number, title, or other brief description so we will know exactly what you want.

WESTINGHOUSE STOKER "MEETS EVERY DEMAND" *says Hotel Manager*





December 2, 1938

Mr. J. A. Schneider
Westinghouse Electric & Mfg. Co.
Louisville, Kentucky

Dear Mr. Schneider:

This is in reply to your inquiry regarding an expression as to the efficiency of the Westinghouse Stoker apparatus installed under our new 400 H. P. Vogt Boiler four or five years ago.

Our Chief Engineer advises that it has given satisfactory service and met every demand made on it at all times, and that it is, in his opinion, a very efficient stoker.

It is a pleasure to write a letter of this kind.

Very truly yours

NEW PHOENIX COMPANY

JGC:go

Manager

"SATISFACTORY SERVICE"

This Westinghouse Moving Grate Stoker was installed in 1931 for the Phoenix Hotel of Lexington, Ky. For eight years it has been giving perfectly "satisfactory service." That means just what it says, and the hotel's experience bears out the statement.

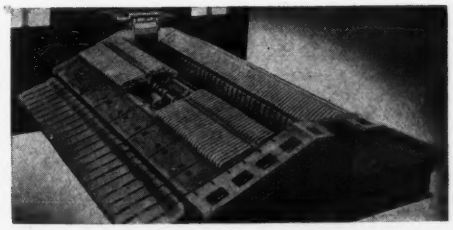
"VERY EFFICIENT STOKER"

The rate of combustion is easily adjusted to changing steam demands, and yet combustion at all rates is efficient. The moving grates of the stoker keep the fuel bed constantly agitated. Grates are kept cool, which means less maintenance cost.

"MET EVERY DEMAND"

Hotel steam and power requirements are subject to extreme variations, but the great flexibility of this stoker meets all demands.

MOVING GRATE STOKER



The wave-like motion of the grates keeps the fuel bed porous, keeps grates cool and free from large clinkers, and effects efficient combustion.

SAVE MONEY IN YOUR BOILER ROOM

Westinghouse combustion engineers are ready to help you make a study of your own plant, and show you how to save money. This service involves neither cost nor obligation. Write, wire or phone any Westinghouse Office.

I-50234

Westinghouse Stokers

WESTINGHOUSE ELECTRIC

Power Plant Construction News

Ala., Lanett—Lanett Bleachery & Dye Works plan installation of electric power equipment in new three-story addition to mill, totaling about 30,000 sq. ft. of floor space. Entire project will cost over $75,000. J. E. Sirrine & Co., Greenville, S. C., are consulting engineers.

Calif., Los Angeles — Fruehauf Trailer Co., 10940 Harper Avenue, Detroit, Mich., plans installation of electric power equipment in one-story addition to branch plant at 2160 East Twenty-fifth Street, Vernon, Los Angeles, totaling about 100,000 sq. ft. of floor space. Cost over $175,000. Proposed to begin work soon.

Conn., Norwalk—Dorr Co., Inc., Danbury Road, Westport, Conn., plans installation of electric power equipment in new chemical and mining machinery-manufacturing plant at Norwalk. Entire project will cost about $75,000. Leo F. Caproni, 1221 Chapel Street, New Haven, Conn., is architect and engineer.

Fla., Dania—Florida Power & Light Co., Miami, Fla., has plans maturing for addition to steam-electric generating plant at Dania, 50 x 100 ft., and 88 ft. high, with installation of new 25,000-kw. turbine-generator unit and accessories, high-pressure boilers using oil fuel, and auxiliary equipment. Entire project will cost close to $3,000,000, including line extensions in Dania and neighboring areas. Completion is scheduled late in 1940.

Ill., Chicago—Commonwealth Edison Co., 72 West Adams Street, has filed plans for new high-tension power substation and switching station at 1121-45 West Cermak Road, to be four-story, 104 x 252 ft. Cost about $500,000, with equipment.

Kan., Sterling—City Council has plans maturing for new municipal electric power plant to replace present city station, with installation to include Diesel engine-generator units and auxiliary equipment. Cost estimated close to $200,000. Proposed to arrange bond issue for project. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

Md., Baltimore—Fairfield Western Maryland Dairy Corporation, 1125 Linden Avenue, plans installation of electric power equipment in new milk and milk by-products plant on Loch Raven Road, where company has tract of 10 acres of land. A power house will be built. Entire project is reported to cost close to $1,500,000.

Md., Frederick—Articaire, Inc., 112 East Church Street, has approved plans for new one-story cold storage and refrigerating plant, with locker system. Cost estimated about $30,000, with equipment. Earl S. Harder, 15 West Street, Annapolis, Md., is architect.

Md., Sykesville—State Board of Mental Hygiene, 330 North Charles Street, Baltimore, Md., has plans under way for extensions and improvements in power plant at Springfield State Hospital, Sykesville, including installation of new equipment. Cost estimated about $100,000.

Md., Vienna—Eastern Shore Public Service Co., Salisbury, Md., has plans maturing for new steam-electric generating station at Vienna, with installation to include a 7500-kw. turbine-generating unit and provision for a second such unit at later date, high-pressure boilers and auxiliary equipment. Extensions will be made in transmission lines. Project will be carried out by Delmarva Power Co., an affiliated interest. Cost estimated close to $1,000,000. Financing is being arranged.

Mich., Adrian—Bohn Aluminum & Brass Corporation, Lafayette Building, Detroit, Mich., plans installation of electric power equipment in new addition to branch plant at Adrian. Entire project will cost close to $125,000. Proposed to begin work soon.

Minn., Moorhead—City Council has authorized additional financing, to make a total appropriation of about $200,000 for proposed expansion and improvements in municipal electric power plant, recently noted in these columns, providing for further expansion in station. Installation will include a new turbine-generator unit and complete auxiliary equipment. Helmick, Edeskuty & Lutz, Essex Building, Minneapolis, Minn., are consulting engineers. Water and Light Board of city is in charge.

Mo., Jefferson City—State Building Commission, Edgar M. Egan, executive secretary of Bi-Partisan Advisory Board, Merchants' Bank Building, plans call for bids early in October for new power plant at local auxiliary prison, with installation to include Diesel engine-generator units and accessory equipment. Cost about $50,000. Also, at same time will ask bids for improvements in boiler house at state prison, with installation of new boilers and auxiliary equipment. Baumes Engineering Co., Railway Exchange Building, St. Louis, Mo., is consulting engineer, both projects.

Mo., Kansas City—Missouri-Pacific Railroad Co., Missouri-Pacific Building, St. Louis, Mo., has filed plans for addition to power house at yards in East Bottoms district, Kansas City, including improvements in present station and installation of equipment. Cost estimated about $55,000.

Mont., Great Falls—Buttrey Foods, Inc., has plans for new one-story cold storage and refrigerating plant, 30 x 100 ft. Cost estimated about $30,000, with equipment. Proposed to begin work soon. Cotter & Herrington, First National Bank Building, are architects.

Ohio, Columbus—Kroger Grocery & Baking Co., 35 East Seventh Street, Cincinnati, Ohio, plans installation of electric power equipment in two-story addition to branch meat-processing and packing plant at 2210 Lockbourne Road, Columbus. Entire project will cost close to $75,000. Tietig & Lee, 34 West Sixth Street, Cincinnati, are architects; A. M. Kinney, Carew Tower Building, Cincinnati, is mechanical engineer.

Ohio, St. Marys—Goodyear Tire & Rubber Co., Akron, Ohio, plans installation of electric power equipment in new branch mill on 60-acre tract of land near St. Marys, recently acquired, to be used for production of mechanical rubber goods. It will comprise several large units. A power house will be built. Entire project estimated to cost close to $1,000,000.

Ohio, Sabina—Village Council plans extensions and improvements in municipal electric power plant, including installation of two new Diesel engine units and accessories. Cost about $42,000. Bond issue of that amount is being arranged, to be approved at general election, Nov. 7.

Ore., Roseburg—Gatewood Lumber & Plywood Co., care of E. E. Gatewood, 2210 Tenth Street North, Seattle, Wash., head, recently organized, plans installation of electric power equipment in new lumber and plywood mill near Roseburg, where tract of land has been acquired. It will consist of several large units. A power house will be built. Entire project is reported to cost over $600,000.

Pa., Du Bois—Du Bois-Martin Aircraft Corporation, Capt. H. R. Martin, president, recently organized, plans installation of electric power equipment in new local airplane-manufacturing plant, for which large tract of land has been acquired. Entire project is reported to cost over $80,000. Proposed to begin work soon.

S. C., Charleston—Century Wood Preserving Co., plans installation of power equipment, in connection with rebuilding of portion of local plant, recently destroyed by fire. Loss estimated close to $250,000.

Texas, Texas City—Republic Oil Refining Co., plans new steam-electric power plant at oil refinery at Texas City, with installation to include turbine-generator unit and accessories, boilers equipped to use oil fuel, and complete auxiliary equipment. Cost estimated about $250,000. O. D. Robinson is president.

Wash., Seattle — Puget Sound Bridge & Dredging Co., 2929 Sixteenth Street, S. W., plans plant for storage and handling of contractors' equipment on Harbor Island, to include boiler house, pumping station, fuel oil tanks with gross capacity of 1,000,000 bbls., shops and other mechanical structures. Entire project will cost over $750,000, including equipment.

Wis., Amery — Wisconsin Hydro-Electric Co., has plans under way for new steam-electric generating station for standby service, with initial installation to include a 3000-kw. generator unit and accessories. Application has been made for permission to proceed with project.

Wis., Milwaukee—Wisconsin Electric Power Co., 231 West Michigan Street, has approved plans for addition to steam-electric generating station on Commerce Street, to be about 80 x 134 ft., and 110 ft. high, with installation to include a new 35,000-kw. turbo-generator and accessories, high-pressure boilers and auxiliary equipment. Proposed to begin work soon. Cost estimated close to $4,100,000.